REPORT

OF

IRRIGATION AND POWER TEAM

ON

RIHAND PROJECT

(Uttar Pradesh)

COMMITTEE ON PLAN PROJECTS

NEW DELHI

(July 1962)

A. N. KHOSLA
Leader,
Irrigation & Power Team.

COMMITTEE ON PLAN PROJECTS
Planning Commission,
Yojana Bhavan,
New Delhi-1

September 12, 1962

My dear Shastriji,

I have pleasure in forwarding to you the Report of the Irrigation & Power Team on the Rihand Project. The Report is the result of close study of all relevant facts and observations of necessary matters. The method followed was to consult the Project Authorities concerned at every step, the dominant thought being to do everything in close cooperation and in a spirit of joint endeavour.

2. Some very pertinent issues have been raised in this Report. They relate to the policy of construction of such dams in masonry versus concrete, departmental versus contract agency, procedures to be adopted in working out depreciation, operation and maintenance and other miscellaneous charges in working out tariffs for electricity, for which there is no uniform practice at present.

3. The Team received fullest cooperation in their studies from the Project Authorities for which our thanks are due to them.

Yours sincerely,

A. N. KHOSLA.

Shri Lal Bahadur Shastri,
Minister for Home Affairs,
Government of India,
NEW DELHI.

CONTENTS

The comments of the Government of Uttar Pradesh and the Central Water & Power Commission have not been received. The statement will be published separately after receipt of the comments.


सत्यमेव जयते

PREFACE

The Committee on Plan Projects, which was set up by the National Development Council in 1956, appoints, from time to time, Teams to make studies of different categories of projects included in the Five Year Plans with a view to securing economy and efficiency in their implementation. One such Team was appointed for the study of Rihand Project *vide* Committee on Plan Projects letter No. COPP/(4)/8/59 dated August 24, 1959.

2. The Team consisted of :

Dr. A. N. Khosla, then Vice-Chancellor, University of Roorkee, now Member, Planning Commission.	Leader.
*Shri Balwant Singh Nag, Adviser, Irrigation & Power, Planning Commission.	Member.
Shri M. P. Mathrani, Chief Engineer (Retd.), Bihar.	Member.

The power aspects of the Project were studied in consultation with Shri N. N. Iengar, Electrical Adviser, Hindustan Steel Ltd., and Consultant to the Irrigation and Power Team.

3. The Terms of Reference required that the Team should make a study of the various aspects of the Project and of the following ones in particular :—

(1) The aspects of the Project having a bearing on economy and efficiency with special reference to,

(a) Utilisation of trained personnel and materials,

(b) Utilisation of machinery and equipment,

(c) Construction Plant layout,

(d) Adequacy of original estimates and designs as evidenced from actual construction of Project,

(e) Phasing of construction with a view to studying whether,

(i) timely utilisation of benefits accruing from the Project has been ensured ;

(ii) it is possible to accelerate accrual of benefits; and

(iii) benefits could be increased by rephasing the Project at this stage ;

(f) Sufficiency of investigations conducted at the Planning stage with a view to the formulation of project estimates, and

*Relinquished charge as Member, Irrigation and Power team on 1·12·1960.

(g) The effect of the above study on the financial results of the Project, if any.

(2) Generally to assess the progress made in construction, the reasons for shortfall, if any, and to suggest measures for improvements in the future,

(3) To examine the possibility of decreasing dependence upon imported materials and equipment required for the Project,

(4) To examine whether adequate steps have been taken by the authorities concerned for fixing and realising the contemplated water rates, betterment fees and/or any other rates, cesses or taxes, and

(5) To report on any other aspect that the Team may like, in order to ensure economy and efficiency in the construction of the Project.

4. The Members of the Team paid a number of visits to the Rihand Project and had detailed discussions from time to time with the Chief Engineers, Irrigation and Power (Rihand Project) and other officials connected with the Project. The Leader along with the Members of the Team visited the Project in September 1960.

5. The Members of the Team discussed the draft Chapter on 'Power Supply, Tariff and Financial Returns' with the representatives of CW&PC and N. R. Division of the Planning Commission on 17th May, 1961. A copy of the Draft Report was forwarded to the Government of U. P., Secretary, Rihand Control Board and the two Chief Engineers, in September 1961 and it was subsequently discussed at Rihand with the two Chief Engineers on 9th October, 1961. In the light of those discussions and subsequent correspondence the Report has now been finalised.

6. The Team would like to place on record its gratitude to the Government of U. P. for the facilities extended for the conduct of investigations and for the ready help given by the Chief Engineers, Irrigation and Power and other concerned officials.

CHAPTER I

HISTORY AND SCOPE OF PROJECT

1.1. The power potential of the Rihand river was first visualised in 1919 by Mr. G. T. Barlow, the then Chief Engineer, United Provinces. Twenty-five years later the prospecting for the dam site at Pipri was done by Shri A. P. Watal, the then Superintending Engineer, Development Circle.

1.2. The site was inspected by eminent engineers such as Dr. J. L. Savage, the then Chief Dam Designer of the Bureau of Reclamation, U.S.A., Shri (now Dr.) A. N. Khosla, the then Chairman of the Central Water, Irrigation and Navigation Commission and Sir William Stamp, the then Irrigation Adviser to the Government of India.

1.3. The investigations and surveys for the preparation of the project were started in 1945. On the basis of the data collected upto that time, a project for the construction of a dam at Pipri was prepared in 1947. This project was sanctioned by the U. P. Government at a cost of Rs. 16·25 crores for the Dam and Power Station only in April 1947.

1.4. The preliminary work on the construction of the project was started in 1948. The general designs and the specifications of the dam, power plant and the appurtenant works were prepared in 1949 in the United States of America by M/s. International Engineering Company in consultation with U. P. Engineers. Unfortunately further work on the construction of this scheme was temporarily suspended in 1949 due to the urgent necessity of transferring of all available personnel, materials and funds to the construction of the short-term food production schemes in order to make the country self-sufficient in food in the shortest possible time.

1.5. In October 1951 when it was decided to resume the work, the project estimate was recast in accordance with the general designs and specifications prepared by the International Engineering Company. The cost of transmission lines and sub-stations was also included in the estimate. This estimate amounted to Rs. 35·21 crores and was sanctioned by the U. P. Government in 1952. The cost of Dam and Power Station alone was Rs. 21·12 crores in comparison to Rs. 16·25 crores in 1948 estimates.

1.6. After the sanction of 1952 project the work on the preparation of a Master Plan for construction of the dam and the power house in concrete was undertaken and completed in 1954. In April 1954 the question of constructing the dam in stone masonry instead of concrete as provided in the estimate was raised by the Central Water and Power Commission. After prolonged discussions between the State Government and the Government of India a decision was taken in favour of a concrete dam. This question has been further referred to in Chapter IV "Construction Features and Construction Programme".

1.7. Soon after the preparation of the master plan, the revision of the 1952 estimate was undertaken on the basis of operations anticipated in the master plan and the rates of labour and materials then prevailing, but the submission of the revised project was deferred pending the result of

the global tenders for the construction of the dam and power house which were proposed to be invited.

1.8. The sealed tenders for the construction of the dam and the power house were received in January, 1955. The rates quoted by the lowest contractors were very much higher than those provided in the 1952 project estimate. It has been stated by the project authorities that the data available for the analysis of unit rate for this type of work at the time of preparation of 1952 estimate was incomplete and meagre, due to which correct rates could not be worked out.

1.9. The lowest tender was approved by the Rihand Control Board on the advice of the Technical Advisory Committee. A revised estimate was thereafter prepared on the basis of rates of the lowest tender and submitted to the State Government for approval in 1956. This revised estimate amounted to Rs. 46·05 crores; this had been administratively approved by the State Government in August, 1958. This estimate included not only the cost of the dam and power house but also of the main transmission lines of 132 KV and 66 KV and the main grid sub-stations and transmission system of 33 KV and below with necessary sub-stations. The cost of the dam and power house in this estimate amounts to Rs. 29·8575 crores. The work of the construction of the dam and the power house is in progress on the basis of this estimate.

1.10. The estimated cost for power generation including the cost of the Dam, Power House and Appurtenant works in the three projects sanctioned from time to time is as under :—

Year of preparation	*Estimated cost for power generation*
	Rs. crores
1947	16.25
1952	21.12
1956 (Revised)	29.8575
1960 (Anticipated cost)	32.87983

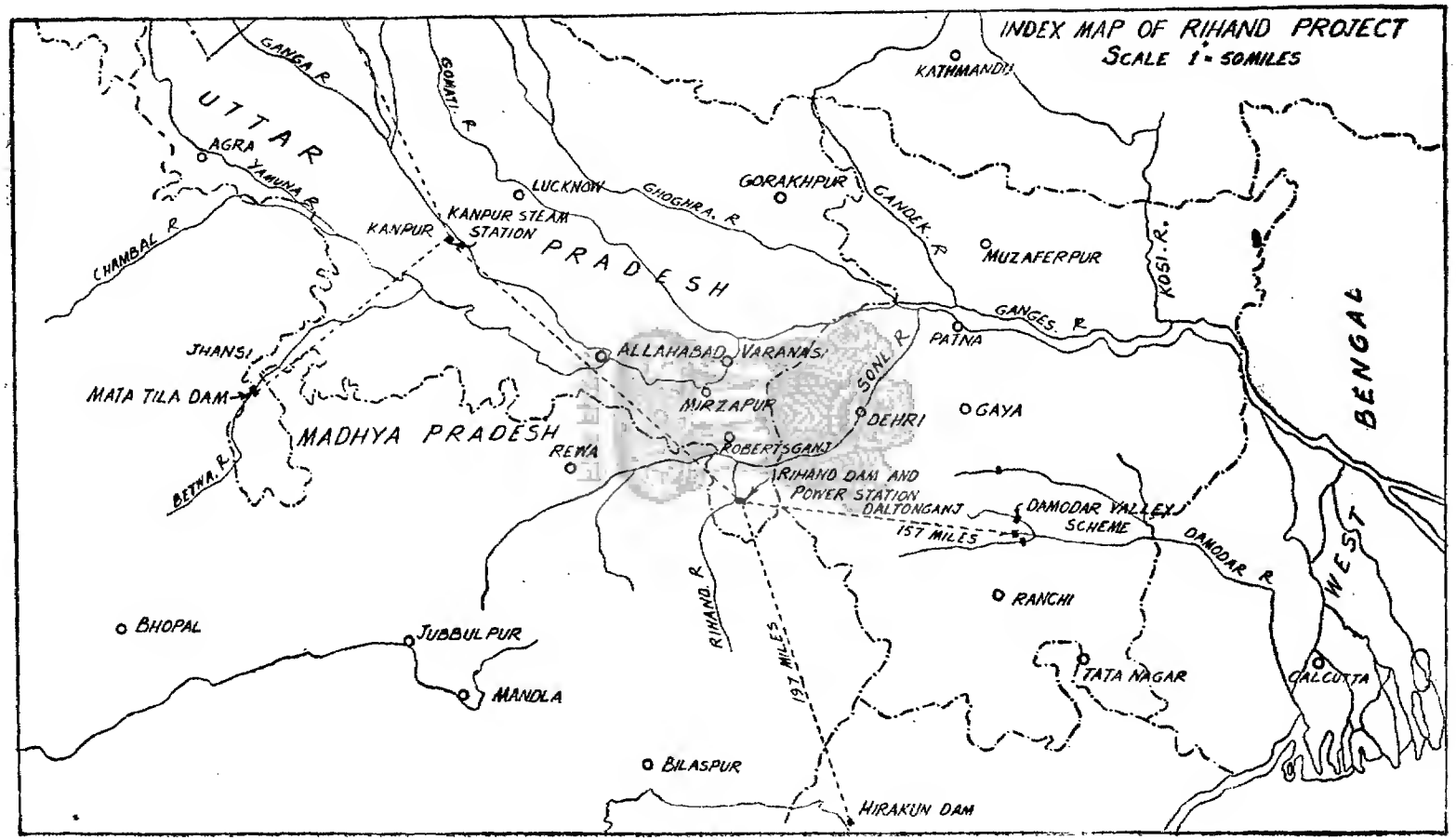
The firm power potential and the installed capacity as provided in the three projects are as under :—

1947 Project :

Firm power potential at 100% LF	1,32,400 KW
Units generated	1160 MKWH
Installed capacity	2,30,000 KW (Consisting of 8 sets of 25,000 KW and 3 sets of 10,000 KW each)

1952 Project :

Firm power potential	1,02,000 KW
Units generated	895 MKWH
Installed capacity	2,40,000 KW (6 sets of 40,000 KW each)


INDEX MAP OF RIHAND PROJECT
SCALE 1" = 50 MILES
KATHMANDU
GANGA R
GOMATI R
UTTAR
PRADESH
AGRA
YAMUNA R
CHAMBAL R
LUCKNOW
GHOGHRA R
GORAKHPUR
GANDEK R
MUZAFERPUR
KOSI R
KANPUR
KANPUR STEAM STATION
GANGES R
PATNA
BENGAL
WEST
JHANSI
ALLAHABAD
VARANASI
SONE R
MATA TILA DAM
MIRZAPUR
DEHRI
GAYA
MADHYA PRADESH
REWA
ROBERTSGANJ
BETWA R
RIHAND DAM AND POWER STATION
DALTONGANJ
DAMODAR VALLEY SCHEME
157 MILES
DAMODAR R
RIHAND R
RANCHI
BHOPAL
JUBBULPUR
MANDLA
197 MILES
TATA NAGAR
CALCUTTA
BILASPUR
HIRAKUN DAM

1956 (Revised) Project :

Firm power potential	1,05,000 KW
Units generated	912 MKWH
Installed capacity	2,50,000 KW (Consisting of 5 sets of 50,000 KW each and room for a 6th set of 50,000 KW at a subsequent date).

1.11. The salient features of the Project as shown in the 1956 revised estimate are given in *Appendix I.* An Index Map of Rihand Project is given at page 3.

CHAPTER II

HYDROLOGY AND POWER POTENTIAL

2.1. The Rihand river above the dam site drains an area of 5,148 sq. miles with an average rainfall of about 56 inches per annum.

2.2. When the work of the preparation of the project was undertaken in 1945 there were only two rain gauges of the Meteorological Department in the drainage basin and a few in the adjoining catchment. A rain gauge station was fixed at Pipri near the dam site in June 1944 and later 13 other rain gauge stations were fixed by the U. P. Irrigation Department. For estimating the run-off, no discharge records on Rihand river were available. There was only one river discharge site at Dehri-on-Sone over the river Sone, which is some 90 miles downstream of the confluence of the Rihand river with Sone. In order to estimate the run-off of the Rihand river at Pipri a study of the record of run-off of Sone river in conjunction with the study of the annual rainfall over the catchment was made. On the basis of this study the following relationship was established for the Rihand catchments :-

$$R = 0.7P - 14$$

R = Run-off in inches

Where P = The mean rain-fall for the area in inches

On the basis of this formula the average annual run-off of the Rihand river was worked out as 7·270 M. Ac. ft.

2.3. As this is mainly a hydro-electric project, the correct estimation of the run-off is a very important factor in determining the power potential of the scheme. The average annual run-off data has been revised as more and more discharge data of the river Rihand at Pipri has become available. This data as provided in the three projects is given below :-

Year of preparation	Average annual run-off M. Ac. ft.	Duration on which average annual run-off is based
1947 Project	7.270	1903 to 1943
1952 Project	6.060	1903 to 1950
1956 (Revised Project)	5.138	1903 to 1955

It will be seen that the average run-off shown in the three projects has decreased as further discharge data has become available.

2.4. The estimation for the run-off for 1952 project was made on the basis of the suggestions made by the International Engineering Company of U. S. A. on the actual run-off data available for the years from 1945 to 1947.

2.5. When 1956 project was prepared actual discharge data of the Rihand river had become available for 10 years. On the basis of this data, further study was made and the following relationship has been established:

$$R = P - 1.17\ P \times 0.865$$

Where R = Run-off in inches

P = the mean rain fall for the area in inches

A statement (2·1) showing the annual run-off from year to year as given in 1947 Project and as now worked out by the Project Authorities along with the observed discharges for the period from 1945-46 to 1959-60 is given below :—

STATEMENT 2·1

Computed annual run-off for the period 1903—1945 from rain-fall run-off relationship.			Observed annual run-off for the period of record 1945—1960.	
Hydrological year.	Run-off as per 1956 revised project.	Run-off as per 1947 project report.	Hydrological year.	Run-off.
	M. Ac. ft.	M. Ac. ft.		M. Ac. ft.
1903—04	3.94	4.805	1945—46	4.67
1904—05	4.56	5.321	1946—47	5.47
1905—06	3.80	4.228	1947—48	3.92
1906—07	5.46	8.045	1948—49	4.91
1907—08	5.24	7.111	1949—50	5.31
1908—09	5.78	8.937	1950—51	8.96
1909—10	4.22	6.265	1951—52	5.95
1910—11	5.05	6.919	1952—53	5.15
1911—12	5.45	8.429	1953—54	3.46
1912—13	3.82	3.549	1954—55	1.89
1913—14	4.61	7.791	1955—56	2.77
1914—15	5.08	6.233	1956—57	6.10
1915—16	5.34	7.784	1957—58	3.35
1916—17	6.55	8.553	1958—59	5.17
1917—18	5.84	9.533	1959—60	5.47
1918—19	5.18	7.015		
1919—20	6.15	12.740	TOTAL .	72.55
1920—21	4.27	5.876		
1921—22	5.16	10.183	Average 4.83 M. Ac. ft.	
1922—23	4.95	6.800		
1923—24	5.61	7.784		
1924—25	5.47	10.472		
1925—26	7.29	9.610		
1926—27	4.71	6.842		
1927—28	4.86	6.842		
1928—29	4.43	5.554		
1929—30	5.51	8.164		
1930—31	5.85	8.553		
1931—32	4.43	6.458		
1932—33	5.05	5.266		
1933—34	4.57	7.207		
1934—35	6.00	7.668		
1935—36	4.90	5.958		
1936—37	7.21	10.667		
1937—38	5.34	6.650		
1938—39	5.09	6.054		
1939—40	6.01	7.592		
1940—41	3.93	5.263		
1941—42	3.32	3.479		
1942—43	5.65	6.977		
1943—44	7.00	9.417		
1944—45	5.23			
TOTAL .	218.94	298.089		
Average : 5.21 M. Ac. ft.		7.270 M. Ac. ft.		
Grand Total : 291.49 as per 1956 Projects (1903-1960)				
Average : 5.11 M. Ac. ft.				

2.6. From this statement it will be seen that the average run-off calculated from the total run-off for the period from 1903-1944 on the basis of new formula and for the period 1945 to 1960 on the basis of actual discharges works out to 5·11 M.Ac. ft. The average run-off, however, for the 15 years period for which actual discharges are available is only 4·83 M.Ac. ft. During the period for which actual discharges are available there has been a period of severe drought for about 3 years continuously from 1953-54 to 1955-56.

2.7. A comparative Statement (2·2) showing the computed run-off by Rihand formula and actual run-off for the period from 1945-46 to 1959-60 for which actual data is available is given below :—

STATEMENT 2·2

Hydrological year.	Computed run-off by New Rihand formula M. Ac. ft.	Actual run-off M. Ac. ft.		Percentage error with respect to actual run-off.
1945—46	5.12	4.67	plus	9.6
1946—47	5.76	5.47	plus	5.3
1947—48	4.81	3.92	plus	22.7
1948—49	5.87	4.91	plus	19.6
1949—50	5.26	5.31	minus	0.9
1950—51	5.37	8.96	minus	40.1
1951—52	4.59	5.95	minus	22.9
1952—53	4.82	5.15	minus	6.4
1953—54	3.58	3.46	plus	3.5
1954—55	3.52	1.89	plus	86.2
1955—56	3.28	2.77	plus	18.4
1956—57	6.56	6.10	plus	7.5
1957—58	3.71	3.35	plus	10.7
1958—59	4.13	5.17	minus	20.1
1959—60	3.85	5.47	minus	29.6

In this statement the percentage error with respect to actual run-off has also been worked out. It will be seen that the percentage error varies from minus 40% to plus 86%. The new formula also therefore does not seem to be quite satisfactory. However, as the power potential has now been based on an average run-off of 5·1 M.Ac. ft. which is the average of the observed annual run-off for 13 years after excluding two exceptionally bad years, it may be expected that the power potential as now assumed is a reasonable basis for integration of the Rihand Project in a regional power net work. This run-off, also more or less, tallies with that given by Khosla Formula as explained later.

2.8. A statement (2·3) showing the run-off calculated in inches over the catchment area as given in three projects and the percentage of the same to average rainfall is given below :—

STATEMENT 2·3

Catchment Average rainfall :		5148 sq. miles 56″	
Year of preparation.	Run-off (M. Ac. ft.).	Run-off (inches).	Percentage of run-off to average rainfall.
1947 Project	7.270	26.5	47.3%
1952 Project	6.060	22.1	39.5%
1956 Project	5.138	16.7	33.4%

In 1947 project Report average rainfall run-off curves according to various formulae have been given at page 18. For an average rainfall of 56″, the run-off according to Khosla Formula is shown as 18·4″ (*vide* enclosed plan at the end of the Chapter). This very nearly tallies with that adopted in 1956 report and also with actually observed data for last 15 years. The percentage of run-off to average rainfall adopted in 1947 Project was very much on the high side considering the location of the catchment.

2.9. The dam has been designed with F. R. L. 880 and dead storage level at R. L. 775. The gross storage capacity is 2·6 M.Ac. ft. and the dead storage is 1·32 M.Ac. ft. This gives a live storage capacity of 7·26 M.Ac. ft. These features of design have been retained in all the three projects. When the dam was originally designed in 1947 the average run-off was taken as 7·27 M.Ac. ft. The economics for the optimum tank level were worked out with different F. R. Ls. and the study showed that the cost of generation was the lowest at F. R. L. 880. At this level the live storage corresponded to the average run-off also, and the firm power potential was worked out as 1,32,400 KW at 100% LF.

2.10. When 1952 project was prepared and the average annual run-off was calculated as 6·06 M.Ac. ft. fresh studies were made by M/s. International Engineering Company to verify the most economical top elevation for the dam. Again the full reservoir level was fixed at R. L. 880 and the firm power potential was worked out as 1,02,000 KW at 100% load factor.

2.11. When 1956 revised estimate was prepared the hydrology was again revised and the average annual run-off came to 5·138 M.Ac. ft. The firm power potential has now been shown as 1,05,000 KW. The average quantity of water required for generation of this firm power is 5·1 M.Ac. ft. including evaporation losses. The average run-off of the river for the period from 1945-46 to 1959-60 for which observed data is available is 4·83 M.Ac. ft. only which is less than that required for generation of designed firm power. The average run-off for the five year period from 1953-54 to 1957-58 works out to 3·5 M.Ac. ft. only. From the operational hydrograph prepared by the project authorities it is seen that there would have been considerable shortage in firm hydro-power of 1,05,000 KW from October, 1954 to September 1957 *i.e.* for only nearly 3 years and a thermal support of 30,000 to 50,000 KW would have been required for

maintaining firm power of 1,05,000 KW. The energy deficit to be made up thermally in this period is of the order of 370 M. units per annum or about 18·0% of average thermal energy generation in a 250 MW thermal power station.

2.12. The construction of a thermal station of 250 MW has already been decided upon in this region with five 50 MW generating units, utilising the coal resources available nearby. With the construction of the thermal station, it should be possible to firm up the hydro energy to the extent assumed in the project in years of drought. From the operational hydrograph prepared by the project authorities for firm power of 1,05,000 KW it is seen that there is surplus water going to waste without generating power in a number of years. The project authorities have also studied the question of raising firm power development to 1,25,000 KW with the support of the proposed thermal station. The spill-over is reduced and average hydro-energy generation can be increased from 920 MKWH to 947 MKWH. Furthermore, with a 250 MW thermal power station in parallel operation, it will be possible to avoid spilling even in good rainfall years, as hydro energy can be made use of to replace thermal power generation. Such spill energy is expected to be available about once in 4 years; it is estimated at 29·7 million units per annum on an average.

2.13. There is scope for further development of hydro power on the Rihand river. There is a suitable site for low lifting dam about 20 miles downstream of Rihand at Obra. It is proposed to exploit this site for development of further 50,000 KW of firm power. This proposal is a promising one ; it would help to improve the overall economy of Rihand Hydro-Electric power development.

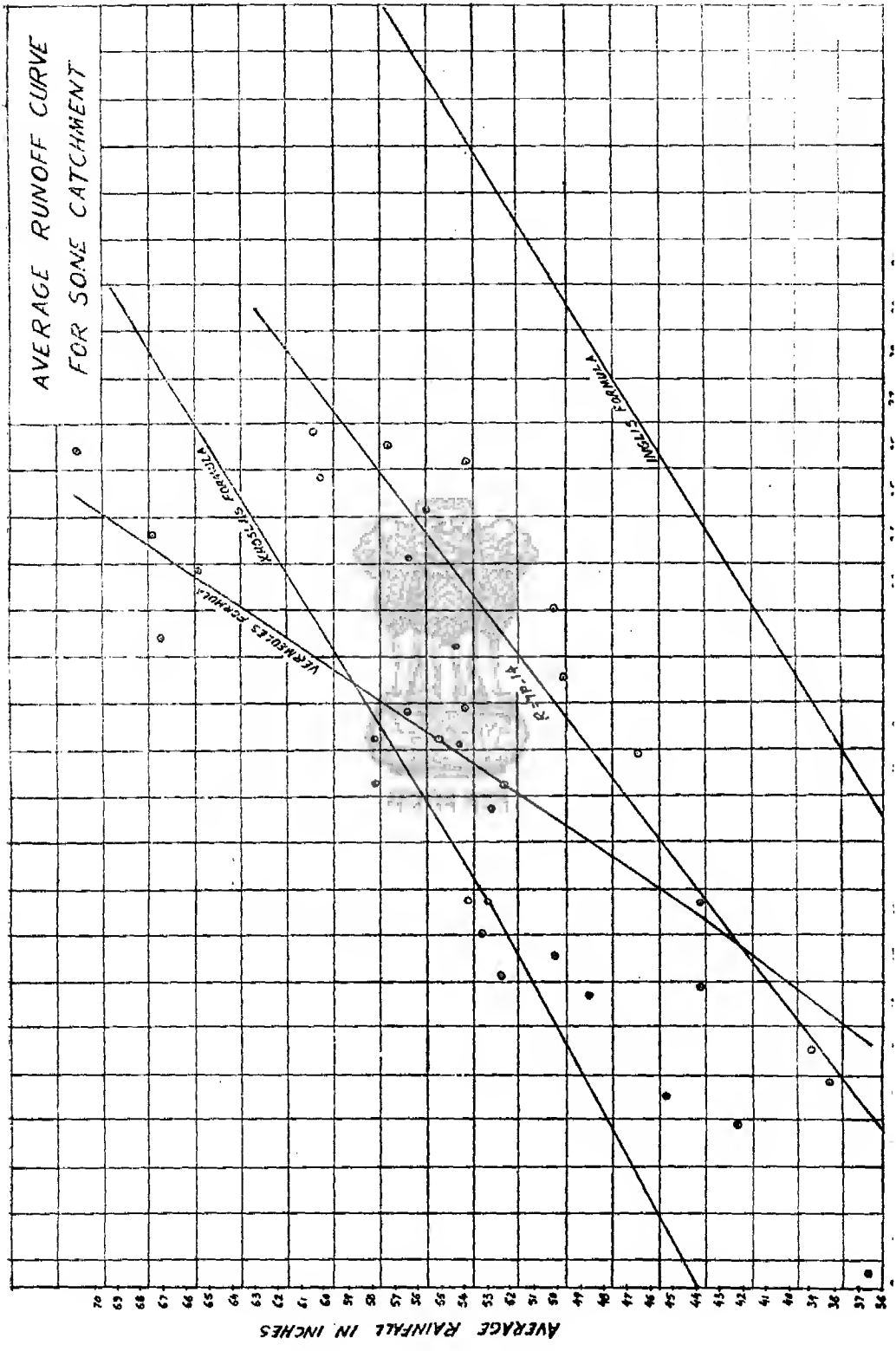
2.14. Almost all the firm power from Rihand Project is already booked and is expected to be utilized by 1965-66. The probable loads, are likely to be as below, all expressed at 100% load factor (for energy) and at respective load factors (for peaking) :—

		Energy at 100% L. F.	Peaking
(i)	Aluminium factory (already sanctioned) (peaking at 90% LF)	50 MW	55 MW
(ii)	Railway (already sanctioned) (peaking at 70% LF)	28 MW	40 MW
(iii)	Churk Cement Factory (already sanctioned) (peaking at 60 LF)	6 MW	10 MW
(iv)	Madhya Pradesh (Stipulated to be given)	10.5 MW	10.5 MW
		94.5 MW	115.5 MW

The firm hydro-energy capacity of Rihand River Station at 100% load factor will be 105 MW. About 2 MW will be utilised in Station Auxiliaries, leaving a balance of 103 MW for transmission and distribution. Allowing for the usual losses in transmission and transformation which are expected to be 4 MW, the net balance available for further distribution for miscellaneous purpose will be approximately only 4·5 MW. At an average

load factor of about 40% hydro-power from Rihand Dam would be available for miscellaneous purposes of about 11 MW, making a total peaking load on the power station of about 133 MW for the present. This load can be supplied firmly by operating four 50 MW generating units.

2.15. The power station at Rihand will accommodate six 50 MW generating units eventually. The present installation consists of five 50 MW units. When the proposed 250 MW thermal power station is commissioned or any other large thermal capacity is connected to the grid it will be economical to instal the sixth 50 MW generating unit also at Rihand Dam and operate the hydro-station for peaking in the integrated power system. Rihand would then utilise its hydro-energy resources with a peak load of 300 MW at a load factor of about 33%.


AVERAGE RUNOFF CURVE
FOR SONE CATCHMENT
AVERAGE RAINFALL IN INCHES
INGLIS
KINGSLAND
VERNEDALES

CHAPTER III

POWER SUPPLY, TARIFF AND FINANCIAL RETURNS

3.1. The cost of generation at bus bars as worked out in 1956 Revised Rihand Project is given below :—

	Rs. lakhs
Working expense of generation per annum	44.54
Interest charges per annum @ 4½ per cent on capital Cost of Rs. 2985·75 lakhs	134.36
Profit per annum @ 1% on Rs. 2985·75 lakhs	29.86
TOTAL .	208.76

The interest during construction will be Rs. 606·00 lakhs. The original cost of the assets according to the Electricity (Supply) Act 1948 will thus be Rs. 2985·75+606·00 lakhs =3591·75 lakhs. As a percentage on the original cost, the total generation cost works out to 5·8 per cent only ; this is markedly low as will be apparent later.

The unit cost is as given below :—

(1) Total units to be generated per annum (on the basis of hydrology) 919.8×10^6 KWH

(2) Units available at 132 KV bus bars allowing 2% as losses and auxiliary consumption 901.4×10^6 KWH . . 901.4 MKWH

Average cost of generation : $\frac{208.76 \times 10^7 \times 100}{901.4 \times 10^6} = 2.32$ nP/KHW

If the profit of 1% amounting to Rs. 29·86 lakhs is excluded, the cost of generation would be : $\frac{178.90 \times 10^7 \times 100}{901.4 \times 10^6} = 1{\cdot}99$ nP.

3.2. The Project Authorities have been requested since May 1960 to send a note on electricity tariff rates which were proposed to be adopted for Rihand Projects. They have not yet supplied the information on this subject but in their latest note they have mentioned that a Tariff Committee consisting of the following officers has already been appointed by the Government to go into the question of rates and suggest various tariffs to be adopted for sale of power :—

(1) Commissioner and Secretary, Irrigation and Power Department, Government of U. P.

(2) Secretary, Industries Department, Government of U. P.

(3) Secretary, Finance Department, Government of U. P.

(4) Director of Industries, Government of U. P.

(5) Chief Engineer (Rihand), Government of U. P.

It has been mentioned that the required note will be furnished after the Committee has finalised its recommendations and these are approved by the Government.

3.3. The working expenses for generation of power *viz.* Rs. 44·54 lakhs per annum as assumed in the Project Estimate for operation, maintenance, repairs and depreciation are indeed very low; a detailed examination of the different items included in this confirms that adequate provisions have not been made in a number of items. The details of the working expenses as assumed in the Project are :—

Generation

Sl. No.	Item	Amount Rs. lakhs
1.	Establishment, leave, pension etc.	9·7
2.	Maintenance and Repairs :—	
Total capital cost Rs. 2201·93	(a) Buildings and structures at 2 per cent on Rs. 48·22 lakhs	0·96
	(b) Dam and power houses and spillway including gates etc. 0·25 per cent on Rs. 1739·80 lakhs	4·35
	(c) Reservoir clearance and rim treatment at 2 per cent on Rs. 25·20 lakhs.	0·50
	(d) Power Plant. 0·75 per cent on Rs. 387·80 lakhs	2·91
	TOTAL .	18·49
3.	Annual Depreciation Reserve :—	
Total capital cost Rs. 2127·60 lakhs	(a) Dam, Power House and Spillway etc. 1 per cent on Rs. 1650·95 lakhs	16·51
	(b) Power Plant etc. 2 per cent on Rs. 387·80 lakhs.	7·76
	(c) Intake, outlet and crest gates, their operating equipment, trash racks etc. 2 per cent on Rs. 88·85 lakhs.	1·78
	TOTAL .	26·05
	GRAND TOTAL .	44·54

The operation and maintenance charges are assumed at Rs. 18·49 lakhs. The charges have been based on a capital cost of Rs. 2201·93 lakhs whereas the total estimated cost of all items of the generation installations amounts to Rs. 2985·75 lakhs; the latter figures again does not include interest during the period of construction. The cumulative total of simple interest at the rate of 4·5% during the period of construction works out to Rs. 606·00 lakhs. The total costs, therefore, for building the generating assets at the commencement of operation would thus amount to Rs. 2985·75 + 606·00 lakhs = 3591·75 lakhs; according to the Electricity (Supply) Act, 1948. Rs. 3591·75 lakhs are considered as the "original cost" of the projects. The assumed operation and maintenance charges *viz.* Rs. 18·49 lakhs amount to only about 0·5% of the original cost. This estimate is certainly very low and is not consonant with experience in any similar projects. Normally such charges are found to amount to about 1·5% of the original cost. We may note that this percentage has been adopted in working out the generation costs in the Koyna Hydro-Electric Project which is generally similar to the Rihand Hydro-Electric Project.

3.4 In actual practice as found in several of the existing hydro-electric power systems in the country, the maintenance and operation charges are even a higher percentage of the original costs of generating installations. As an instance in the Mysore system the operation and maintenance

charges of generation have recently been amounting to 3·5% and above. This is evidently due to the inclusion of the cheaper original costs of the earlier installations in the present total original costs of generation assets. Further operation and maintenance charges at present have to include all varieties of new taxes that Electricity Boards have to pay *viz.* sales taxes and excises, municipal levies, various employees benefits etc. In the case of Rihand Project it would therefore be not far from probable actuals to assume the operation and maintenance charges as 1·5% also of the original cost of the generation assets as in the case of Koyna Project. However, the Team considers that the provisions should not be less than 0·75% of the original cost of civil works as Dam, Buildings, Roads etc., and 2% of the original cost of all generating equipment etc. This approximately gives 1·1% on the total original cost of generation.

3.5. The Team notes that the annual depreciation charges on different categories of plant have been assumed *ad hoc* and not estimated on any recognised basis. Even the full cost of installing the assets has not been taken for calculating the percentage depreciation charges.

The total cost of the assets including interest during construction amounts to Rs. 3591·75 lakhs; whereas the cost of the assets as reckoned for depreciation calculations amounts to only Rs. 2127·60 lakhs.

It is necessary to estimate the depreciation charges in accordance with the method outlined in the Seventh Schedule of the Electricity (Supply) Act of 1948 so that depreciation reserves may be built up adequately. As worked out later on, the total depreciation charges calculated according to the Electricity (Supply) Act on the Straight-line method, would amount to 1·17% of the original cost of the generation assets. On the original cost of Rs. 3591·75 lakhs the depreciation charges would amount to Rs. 42·00 lakhs. The provision in the project namely Rs. 26·05 lakhs is therefore much under estimated.

3.6. The Project estimate provides interest charges at 4·5% on a capital cost of Rs. 2985·75 lakhs; the latter does not however include the interest charges during construction. According to the Electricity Act requirements, interest charges should be added to the other costs of creating assets *i.e.* all costs of construction plus interest charges on borrowed capital during construction are together to be reckoned as the original cost of the assets. Interest charges at 4·5% should therefore be calculated on Rs. 3591·75 lakhs; these would amount to Rs. 161·63 lakhs. The project provides Rs. 134·36 lakhs only for interest.

3.7. In addition to the operation and maintenance and depreciation charges provision is normally made for contingencies and general reserves while working out generation cost. The project provides 1% for profit on the assumed capital cost of Rs. 2985·75 lakhs. According to the Electricity (Supply) Act the annual provision for reserve is not to exceed 0·5% per annum of the original cost of the fixed assets so that the total standing to the credit of such reserve shall not exceed 8% of the original cost of the fixed assets. Normally 0·5% is appropriated for such reserve for working out the generation cost. The provision for this item would therefore be 0·5% on the original cost of Rs. 3591·75 lakhs; this would amount to Rs. 17·96 lakhs. Estimating at 1% on a lower capital cost *viz.* Rs. 2985·75 lakhs the project provided Rs. 29·86 lakhs as profits.

3.8. If the cost of generation had been worked out in accordance with the provisions of the Electricity (Supply) Act, 1948, and the operating experiences of similar existing power systems it would have been as follows :—

	Rs. lakhs
1. Operation and maintenance charges at 0·75% of the original costs of dam etc. and 2% on the original cost of power house & equipment etc.	36·40
2. Annual contribution to Depreciation Reserve 1·17% on the total cost of generating assets *i.e.* Rs. 3591·75 lakhs.	42·00
3. Contingency and General Reserve 0·5% on the above amount .	17·96
4. Interest charges per annum at 4·5% on the above amount . .	161·63
TOTAL .	257·99

Total energy available as shown above : 901·4 MKWH

Average cost of generation : $\frac{256 \cdot 99 \times 10^5 \times 100}{901 \cdot 4 \times 10^5} = 2 \cdot 85$ nP.

Inclusive generation cost thus works out to 2·85 np per KWH at bus bars at the power station if based on the capital cost of the Projects as estimated in the 1956 revised estimate.

3.9. If depreciation charges are worked out on sinking fund method for incremental deposits only without allowing for interest on the accumulated balances in the reserve which the Project Authorities have suggested in the latest data supplied by them as mentioned hereafter, such charges would be Rs. 15·81 lakhs against Rs. 26·05 lakhs as shown by the Project Authorities in 1956 estimate. The overall cost of generation even on this basis would be :—

	Rs. lakhs
(i) Operation and maintenance charges at 10·75% of the original costs of dam etc. and 2% on the original cost of power house and equipment etc.	36·40
(ii) Annual contribution to Depreciation Reserve on sinking fund method without allowing for interest on the accumulated balances in the reserve on the total cost of generating assets *i.e.* Rs. 3591.75 lakhs.	15·81
(iii) Contingencies and general reserve 0·5% on the above amount .	17·96
(iv) Interest charges per annum at 4·5% on the above amount . .	161·63
TOTAL .	231·80

Total energy available as shown above : 901·4 MKWH

Average cost of generation : $\frac{231 \cdot 80 \times 10^5 \times 100}{901 \cdot 4 \times 10^6} = 2 \cdot 59$ nP/KWH

3·16. The Team has been informed that a contract has been entered into with the Hindustan Aluminium Corporation Limited for the supply of energy from this project of about 55 MW of firm power at a unit rate of 1·997717 nP. It is estimated that the Aluminium Factory will consume

this power at 90% L.F. or 434 MKWH per annum, which amounts to nearly 50% of the total average energy available for sale at the power station. According to the 1956 Revised Estimate the cost of generation was worked out at 1·99 nP per unit allowing for working expenses, depreciation and interest charges only but no profit. It would appear that the sale of energy to the Aluminium Factory has been contracted for at the estimated average cost of generation at the power house as shown in 1956 revised estimate. It is doubtful however if 50% of the total power potential of the Rihand Project would have been contracted for at such a low rate, if the project had made adequate allowances, according to provisions in the Electricity (Supply) Act, for all expenses in the cost estimates and if it had been realised that the actual generation cost would probably amount to slightly less than 3 nP as is now worked out instead of slightly less than 2 nP as was assumed in the project.

Further it may be mentioned that this contract for supply of electrical energy to Messrs Hindustan Aluminium Corporation Limited has been finalised for a period of 25 years and the rate of 1·997717 nP per KWH cannot be revised for a period of 16 years. For the remaining period of 9 years it can be revised depending upon the relevant factors, but the enhancement in the rate shall not exceed 10% of the rate contracted, *viz.*, the unit rate cannot exceed 2·197488 nP. Such long term fixity of rates is totally at variance with present experiences with trends of production costs in commerical or utility undertakings.

3.11. The questions of up-to-date revised project cost and operation and maintenance charges and depreciation have been discussed with the Project Authorities. The revised capital cost of generation has been estimated as Rs. 3287·983 lakhs and interest during the period of construction is worked out as Rs. 667·401 lakhs. The total capital cost of generation including interest or the original cost of the generation assets now works out to Rs. 3955·384 lakhs.

3.12. It is necessary to revise the various items of generation cost on the revised estimates of the capital costs of the project. They will be as under :—

(i) **Operation & Maintenance.**—These charges have been worked out afresh by the Project Authorities and amount to Rs. 20·77 lakhs (*vide copy of their appendix III*). The Project Authorities have now also estimated their working expreses not only on part of original costs of generating assets. *viz.*, on Rs. 3955·384 lakhs but only on part of original costs which amount to Rs. 2301·597 lakhs. This amount, *viz.*, Rs. 20.77 lakhs represents only 0·52 per cent of the original costs. As has already been mentioned this is an unusually low percentage to assume for operation and maintenance charges. A realistic estimate would increase this provision very considerably, basing it as mentioned above, at 0·75 per cent on original costs of civil constructions and 2% on original costs of power house and all generating equipment.

(ii) **Depreciation.**—The Project Authorities have this time calculated depreciation according to the seventh schedule of the Electricity (Supply) Act, 1948. They have adopted the sinking fund method. It is noticed, however, that the provisions cover only incremental deposits according to this method ; no provision has been made for interest on the accumulated balances in the reserve as required by Section (68) sub-section (2).

While in actual accounting and book-keeping in a power system, it would be known definitely in any year what the depreciation reserves have amounted to and what therefore should be the interest to be debited that year to the reserves, it is not practicable to estimate correctly in this manner, what the average depreciation charges should be for reckoning average generation costs for tariff purposes. It should be admitted that for the purpose of estimating the average generation costs, the average annual depreciation appropriation from revenues should be the same over the period of the plant's life whether the reserves are built up by the sinking-fund method or by the straight-line method. The total depreciation in both cases during the life of the plant should amount to 90% of the original cost. The sinking fund method permits smaller appropriations for depreciation in the early years when the plant is not likely to be loaded fully and the revenues from energy sales would be a portion only of the potential of the project. The straight-line calculation offers a simple and practical means of estimating the equivalent average annual depreciation charges; this method is always used for estimating the average costs in the power system and for framing tariffs based on such costs for sale of power.

The Project Authorities have now estimated total depreciation on the generating plant as Rs. 17·41 lakhs (*vide App. II*), taking only the incremental deposits according to the sinking-fund method. Full depreciation charges are obviously not covered by these provisions. According to the straight-line calculation the depreciation amounts to Rs. 46·96 lakhs (*vide Appendix II*). On an original cost of Rs. 3955·384 lakhs the annual depreciation of Rs. 46·98 lakhs represents 1·17 per cent.

The Team wishes to refer in this connection to arguments one sometimes hears when discussing depreciation provisions in the Electricity Supply business that the provisions would be adequate if annual increments according to sinking fund method only are included in the cost calculation and not the interests on accumulated balances in the reserves. The plea in this argument is that the annual sinking fund increments only should be reckoned for tariff-framing and for recovery from the consumers and the interests on accumulated balances in the reserves should accrue from the use of the funds in the business. The Team submits that the directions to the Electricity Boards in the Electricity (Supply) Act are specific in this detail [*vide Sec.* (68) *sub-section* (12)] and that how the boards utilise the depreciation reserves from year to year is not relevant to the question of estimating the inclusive costs of rendering power service and framing power tariffs to recover all of such costs. Even on a factual basis, power plant equipment depreciates steadily year after year and the only practical and also equitable method of recovering the depreciation costs from the power consumers, who are to be served from that plant, is to estimate the average annual depreciation and recover that in full from the revenues of power sales year after year. In expanding power systems, as Indian power systems will be for several decades, there will always be plant to be added and plant to be retired; depreciation reserve is, however, built up gradually from yearly contributions, whereas corresponding plant renewals will occur intermittently. There will always, therefore, be balances in the depreciation reserve accounts. The proper use of such reserves in the business itself along with other internal resources which are referred to later on, will help to maintain and improve the power systems operating efficiency and thus benefit the consumers. Improved equipment can be installed to realise greater operational efficiencies before old equipment reaches its allotted life. It would be poor economy to invest incremental depreciation

appropriations in a bank and load the power system with increased interest charges for borrowing funds to keep the system up-to-date and efficient. Depreciation charges must be recovered in full from the consumers and they should in return enjoy improved services that can only be maintained by proper use of the financial resources in the supply business.

3.13. It may further be mentioned that clause VI of the sixth schedule of Electricity (Supply) Act 1948 provides that a licencee may elect to appropriate annual contributions to depreciation reserves either by the compound interest method or the Straight-line method. It is significant that the clause describes both options as methods of depreciation accounting; it is implied that both methods will provide at the end of the prescribed life of the plant, a depreciation reserve equal to 90% of the original cost of the plant. It is further definitely mentioned that the annual interest on accumulated balances in the case of compound interest method will be treated as an expense from revenue *i.e.* it is to be recovered from power sales only as no interest is allowed on depreciation reserve in the case of licencee's power supply systems. The Team maintains that the compound interest method of depreciation accounting must be the same in the case of Electricity Board consumers also, as the Electricity (Supply) Act was never designed to discriminate between different groups of electricity consumers in this respect.

3.14. The Team feels that there is need to clarify thinking on this question of depreciation, its determination and accounting as different view points are often expressed and no uniform basis is followed in preparation of various hydro-electric projects. It would be profitable if the Irrigation and Power Ministry considered appointing an expert committee to standardise and recommend practices in this aspect of utility management.

(iii) **Contingency, General reserve and interest charges.**—The other generation expenses *i.e.*, contingency and general reserve would be 0·5 per cent and interest 4·5% both calculated on the original cost.

3.15. The total generation costs based on the 1960 revised costs of the generation assets, *viz.*, Rs. 3955·384 lakhs would be:—

		Rs. lakhs
(1)	Operation and maintenance charges at 0·75% of the original cost of civil works amounting to Rs. 3092·039 lakhs and 2% on power house and equipment amounting to Rs. 863·347 lakhs	40·45
(2)	Annual depreciation charges	46·98
(3)	Contingency and general reserves at 0·5%	19·78
(4)	Interest charges per annum at 4·5%	177·98
	TOTAL .	285·19

Total units available as before : 901·4 MKWH

$$\text{Average cost of generation} : \frac{285{\cdot}19\times10^5\times100}{901{\cdot}4\times10^6} = 3{\cdot}16 \text{ nP/KWH.}$$

On the basis of sinking-fund method for depreciation without allowing for interest on the accumulated balances in the reserve which the Project Authorities have suggested to be adopted the average cost of generation for the revised capital cost of Rs. 3955·384 lakhs would be 2·85 nP/KWH. As already stated the Team considers that this will not be a realistic cost of generation.

As 434 m. units of energy have already been contracted to be sold to the Hindustan Aluminium Corporation Ltd. at 1:997717 nP. per unit, the revenue from the same would amount to Rs. 86·8 lakhs annually. The balance of the generation costs of the project would have to be recovered from sales of the balance of the average energy potential of the project, *viz.*, (901-434)=467 m. units. The balance of the generation costs to be realised would be (285·19—86·8 lakhs)=Rs. 198·39 lakhs. As this has to be recovered from the sales of 467 m. units, these will need to be sold at an average price of 4·25 nP/KWH. The rate of 4·25 nP per unit at the generation station is relatively a high cost for hydro-power for use for general purposes. It was the intention originally of the Project Authorities to make cheap hydro-power available for the undeveloped and economically very backward area for cottage industries and lift irrigation. It does not appear to be feasible to achieve the original programmes in the way the project has developed so far.

3.16. The Project Authorities had originally estimated the net yield of 5·5% from the working of the project. The latest financial forecasts based on up-to-date costs revised in 1960 show an ultimate net yield of 7·4%. The calculations mentioned in this chapter, however, indicate that it will not be possible to realise either of these forecasts even if the balance of power now available for other purposes is sold at the high generation cost of 4·25 nP per unit. The net yield even then would only be about 4·5%, barely-sufficient to meet interest on borrowed capital after providing 0·5% for contingencies and general reserves.

3.17. The 1960 revised estimate of generating assets is Rs. 3955·384. Sale of the full power potential must realise at least Rs. 285·19 lakhs annually to recover all the costs considered upto now. This represents a gross yield of 7·22 per cent on the original costs of generating assets. Experience is proving that this yield is hardly adequate to meet all the actual costs in operating power systems at present. Various costs have actually to be met that have not been specifically mentioned or provided for in these discussions. Working capital is necessary for operation; interest has to be paid for procuring such funds. Plant and workers must be insured against accidents. There may be damages due to flood and hurricanes and losses due to strikes and mal-operations. Plant replacements will certainly cost more than current depreciation provisions. There must threfore be some reserve to meet such expenses and avoid fluctuations in tariffs for power sales or surcharges that would otherwise become necessary, as the boards are not to operate at a loss. The Team considers that electricity supply tariffs should be revised where necessary, so that a special reserve may be built up to meet such liabilities. The Team suggests that a special provision of at least 1% of the original costs should be made, when recurring costs are reckoned for making tariffs.

3.18. The Team has been informed that the Committee appointed to frame general tariffs for the sale of Rihand power has not yet completed its deliberations. The Team trusts that the Committee will duly take into account all the details of costs as discussed in this chapter.

CHAPTER IV

CONSTRUCTION FEATURES AND CONSTRUCTION PROGRAMME

4.1. Prior to the commencement of the work on the Rihand Dam in 1954 two estimates had been sanctioned, one in 1947 and another in 1952, as already stated in Chapter I on 'History and Scope of Project'. Both these estimates were based on the design of the dam with gravity type concrete construction. In February 1954 the Chairman, Central Water and Power Commission, inspected the Rihand Dam site, where the foundation work was in progress. After inspection of the dam and considering the various factors at the site it was suggested by him that the dam could be built preferably in some stone masonry instead of concrete and that this would result both in economy, employment of local labour and immediate start on the work. When these views were communicated to the Chief Engineer-in-charge of the Rihand Dam Project, he informed the C.W. & P.C. that it would not be advisable to construct the Rihand Dam in stone masonry on account of the following three main reasons :—

(I) Safety of the dam and quantity of masonry involved.

It was stated by him that on account of human factor involved uniformity in quality of masonry cannot be ensured, therefore, the maximum allowable principal stress for rubble masonry cannot safely be taken more than 250 lbs., per sq. inch, as against about 350 lbs. per sq. inch or more which can be safely adopted for properly designed and manufactured concrete. The maximum principal stress in the case of the Rihand Dam for the section adopted for concrete construction works out to 352·5 lbs. sq. inch. The same section would not be safe if the concrete construction was replaced by the rubble masonry construction in reaches, where the height of the dam was more than 200 ft. The height of the Rihand Dam in the deepest portion is 296 ft. The maximum height of the highest rubble masonry dam constructed in India upto that time was 270 ft. only in case of Wilson Dam. No tests had been made to find out the maximum stress which rubble masonry laid *in situ* can bear. If the Rihand Dam was constructed in rubble masonry, the section will be much bigger in comparison to that for the concrete dam and the lower portions will have to be laid in much richer cement mortar or in concrete. This would considerably increase the quantity of masonry in comparison to that required in concrete dam. The consideration of the safety of the dam was very much pressed by the Chief Engineer.

(II) Cost of construction of the dam in stone masonry.

It was estimated by him that the cost of the rubble masonry dam would be about Rs. 3·5 crores more than that of the concrete dam. This was based by him on certain analysis of rates for rubble masonry and concrete. A rate of Rs. 177.7 per 100 cft. was worked out by him for rubble masonry and Rs. 200·6 per 100 cft. for concrete.

(III) Time required for construction of rubble masonry dam.

The rubble masonry dam would take about 12 years to construct against about 6 years for the concrete dam.

4.2. As the CW & PC had different views on this subject, the Government of India appointed a Committee of experts to report on this question. The Committee consisted of the following :—

(1) Shri A. C. Mitra, Chief Engineer, U.P.	Member (Convener)
(2) Shri H. L. Vadera, Member, CW&PC New Delhi.	(Member)
(3) Shri A. M. Kamora, Chief Engineer, Damodar Valley Corporation, Calcutta.	(Member)
(4) Shri M. S. Thirumale Iyengar, Chief Engineer, Hirakud Dam Project.	Member (Chairman).

This Committee gave its report in May 1954 favouring in general the construction of the Rihand Dam in rubble masonry on the following grounds :—

(i) That it would be safe and feasible to construct the dam in rubble masonry.

(ii) That it would cost about Rs. 1.9 crores less than the concrete dam. This was based on a difference of Rs. 35 per 100 cft. between the rates of concrete and rubble masonry. The rate for concrete was assumed as Rs. 185 and that for rubble masonry as Rs. 150 per 100 cft.

(iii) That the rubble masonry dam would take only about 9 months more for completion than the concrete dam.

(iv) That it would give greater scope for employment of both skilled and unskilled labour than the concrete dam.

Shri A. C. Mitra however gave a dissenting note, more or less giving the same objections, which had been given by him previously.

It would appear that the construction materials were considered suitable both for rubble masonry and concrete.

However as the U.P. Government considered that no risks should be taken for a dam of that magnitude which had a very big storage of 8.60 M.Ac. ft. and that it would take longer to construct the dam in stone masonry than in concrete, the Government of India gave its approval to construct the dam in concrete.

4.3. Since June 1954 when these discussions took place, considerable further experience has become available from the construction of a number of dams of the height of Rihand Dam. This should be very useful in connection with the construction of future dams, where suitable building materials are available both for rubble masonry and concrete.

This Team has done the study of two other dams namely Koyna and Nagarjunasagar which are approximately of the same height as the Rihand Dam. It would be of interest to make a few observations on this subject pertaining to these three dams.

The height of these three dams in the deepest portion and the type of construction adopted are as under :—

Name of dam	Height	Type of construction.
1. Nagarjunasagar Dam . .	370 ft.	Rubble masonry.
2. Koyna Dam . . .	345 ft.	Rubble concrete.
3. Rihand Dam . . .	296 ft.	Plain concrete.

4.4. The Nagarjunasagar Dam has been designed as a rubble masonry dam from the commencement when the first joint project was prepared in 1954 by Andhra Pradesh and Hyderabad State. Before the work was started, a project estimate was prepared in 1956. In this estimate the dam was designed to be constructed in rubble masonry in 1·4 red cement mortar with coarsed rubble masonry facing for a thickness of 9 ft. in rich red cement mortar 1 : 2·75. Concrete fas provided in the toe regions where the stresses exceed twenty tons per sq. ft. (about 310 lbs. per sq. inch) and also on the rear face of the spillway portion.

As a result of tests since made on rubble masonry sample blocks both, in U.S.A. by the Bureau of Reclamation and at the Masonry Testing Station at Hirakud where tests can be done upto 4.5 million pound compression, it has been found that the rubble masonry laid to proper specifications is as good as cement concrete if not better for the same cement content of mortar. The Hirakud Testing Station results indicate that "rubble masonry in 1 : 4 cement mortar utilising only 243 lbs. of cement per cu. yd. of masonry gives as good a compressive strength as 1 : 10.28 to 1 : 10.57 cement concrete requiring 330 lbs. of cement per cu. yd. Rubble masonry can safely be adopted for high dams with a designed section no more than a concrete one". These results are given in the printed "Technical Memorandum on the 4·5 million pound Testing Station for concrete and masonry" by M. S. Thirumale Iyengar.

When the test results from the U.S.A. Bureau of Reclamation and Hirakud Testing Station became available, a Stress Committee of CW & PC was appointed in connection with the question of replacement of concrete by masonry in the highly stressed portions of Nagarjunasagar Dam Project.

This Committee consisted of :—

(*i*) Shri Kanwar Sain, Chairman, CW & PC.

(*ii*) Dr. K. L. Rao, Member, CW & PC.

(*iii*) Shri George Oomen, Director, CW & PC.

This Committee recommended in their report that concrete in the regions of Nagarjunasagar Dam, where stresses are more than 20 tons per sq. ft., may be replaced by masonry in 1:3 cement mortar provided proper precautions are taken to lay it according to specifications during construction. Now the Nagarjunasagar Dam is being constructed entirely in rubble masonry with mixes of mortar in various zones as given below :—

(i) For zones where stresses are below 15 tons per square foot.	Mortar 1 : 4·7 strength of Mortar after end of one year 120 tons per square foot.
(ii) For zones where stresses are between 15 and 20 tons per square foot.	Mortar 1 : 3·91 strength 160 tons per square foot.
(iii) For zones where stresses are more than 20 tons per square foot and for the upstream face of the dam for 9' depth.	Mortar 1 : 3 strength 240 tons per square foot.

Thus on the score of safety of design and section, the test results have shown that rubble masonry properly laid can be as good as concrete of similar composition. At the time, the question of Rihand Dam construction had to be decided, these test results were not available, hence perhaps the fears expressed by the Chief Engineer Rihand Dam could not be allayed.

4.5. The total quantity of concrete involved in the Rihand Dam is about 59 million cft. This has been completed in 5 working seasons. The bulk of the quantity amounting to about 56 million cft. has been completed in 3 working seasons as reported by the Project Authorities. The maximum quantity done on one working season is about 25 M. cft.

The total masonry involved in the Nagarjunasagar Dam is about 160 million cft. out of which about 72 million cft. have been done by 1961-62. This has been done in about 4½ working seasons. It may be mentioned that the progress of masonry had to be slowed down in earlier years due to shortage of funds. The Project Authorities hope to do about 28 million cft. in 1962-63 and complete the masonry in 7½ working seasons.

These figures are given as an illustration and not for the purpose of comparison as the working space conditions etc. are different at the two places.

The up-to-date experience on Nagarjunasagar Dam is, however, an indicator that the progress on the rubble masonry construction in a Dam can be competitive with progress on concrete construction in a dam provided other conditions of availability of skilled and unskilled labour and suitable stone etc., are favourable.

4.6. A rough comparison of the rates of different types of construction may be useful for the construction for the three types of dams mentioned above may be given in general terms on the basis of information supplied by the Project Authorities :—

(i) Rubble masonry in 1 : 3:91 red cement mortar is being done at Nagarjunasagar. The rate for this masonry including the extra cost of cement and all other overheads as worked out by the cost accounting organisation of the project every month comes within Rs. 135 per 100 cft. at present at Nagarjunasagar. From the analysis of the rate prepared by the Project Authorities for the trestle-stage masonry also, it is seen that the rate will be about the same. This rate may slightly increase if full depreciated value of equipment required for laying masonry is not realised.

(ii) The rate of rubble concrete for Koyna Dam as indicated in that report is Rs. 190 per 100 cft. This is based on use of 44% rubble and 56% concrete. This rate is likely to be exceeded as the percentage of rubble which was expected to be 44% is not being realised in actual construction. On the basis of 35% of rubble which is approximately being used at present the rate would be about Rs. 200/- per 100 cft.

(iii) The rate for concrete for Rihand Dam works out to about Rs. 23.615 per 100 cft. (*vide Statement* 7.1, *Chapter VII*).

It is very difficult to make a realistic comparison as there are several varying factors of lead, lift and availability of materials etc. at different dam sites. Besides, the overheads are likely to be different depending on whether the work is done departmentally or by contract. No allowance is made in the above figures for the same. The above figures, however, give a general indication of the trend of rates for different types of dam constructions.

4.7. The Team has discussed this subject in the report as there is sometimes controversy regarding cement concrete *versus* masonry for the construction of dams and because the experience obtained on the construction

of the above-mentioned dams of 300-370 ft. height will be useful in deciding upon the type of construction for future dams specially where building materials are suitable both for the construction of rubble masonry or concrete.

It would be useful if a comprehensive study of this general question is made specially as the construction work on the three dams is much advanced now and more factual data of costs and rate of progress etc. will be available.

4.8. The original programme of concreting on Rihand as prepared in October 1955 and as actually done by the contractors are indicated below :—

	Original programme	Actually obtained
	lacs cft.	lacs cft.
I. Season January 1957 to September 1957 (concrete placement was actually commenced in April 1957)	34.17	11.0
II. Season October 1957 to September 1958 . . .	191.00	152.0
III. Season October 1958 to September 1959 . . .	175.33	249.0
IV. Season October 1959 to June 1960	146.50	159.0
V. Season October 1960 to June 1961	53.00	11.0
		Upto March 1961.
	600.00	582.0

The actual quantity is expected to be about 586 lacs cft. The progress in the first two seasons was rather slow which was due to unforeseen delays in procurement of construction plant specially the two 20-tons cableways. This was however made up in the III and IV seasons. As a matter of fact in the latter part of the IV season the work had to be slowed down as the guides, tracks and other embedded parts for the penstock gates were not received in time from Messrs Texmaco to whom the contract for the penstock gates had been let out. According to the terms of the contract of Messrs Hindustan Construction Company the Dam was to be built before June 1960 upto a stage that water could be stored in the Rihand Reservoir upto EL 820. In view of the above difficulties, concreting in some of the spillway bays had to be kept low and special arrangements had to be made to raise such spans later on.

The target of storing water in the Rihand reservoir upto EL. 820 was, however, achieved in spite of initial delays in the procurement of construction equipment and subsequent slowing down of the concreting due to delay in supply of parts of penstock gate guides by M/s. Texmaco by making special arrangements.

4.9. The delay in supply of penstock gates and the auxiliary parts also resulted in considerable extra expenditure in making special arrangements as well as in serious anxiety to the project authorities for the completion of work in time and certain amount of risk involved to the safety of the works. Pending the installation of the penstock gates, the penstocks had to be blocked by means of hemispherical bulk heads which will be cut and removed to enable the power plant to be tested and commissioned which can be done only after the penstock gates are installed. Three of the hemispherical

bulk heads fabricated locally at site of works were not designed to withstand the water pressures higher than with reservoir EL at 820 with the desired factor of safety, whilst it was estimated that these would be subject to higher water pressure resulting from filling of the reservoir to EL 870 during the monsoon season of 1961 on account of failure of M/s. Texmaco to supply the penstock gates in time.

4.10. A brief history of the contract for the supply of penstock gates may be given. The global tenders for the supply of penstock gates, hoists, tracks and guides etc. were invited by the Project Authorities and these were received on 1-11-1956. After prolonged discussions with Central Water and Power Commission, the tender of Messrs Marshall Sons, which was the lowest, was accepted and they were so informed telegraphically on 6-4-1957. The cost and the foreign exchange component involved in case of tender of Messrs Marshall Sons would have been Rs. 17.52 lakhs and Rs. 16.35 lakhs respectively.

Shortly afterwards, Messrs Texmaco represented to Government of India that the contract be awarded to them as their offer would require less foreign exchange. A meeting was therefore held on 10-11-1957 with Central Water and Power Commission and on their specific advice Government of India decided on 10-11-1957 that the contract be awarded to Messrs Texmaco and foreign exchange was also released in their favour. The acceptance of the tender of Messrs Marshall Sons was thereafter cancelled and the contract was awarded to Messrs Texmaco on 24-4-58. The cost and foreign exchange component involved in the contract to Messrs Texmaco are Rs. 21.54 lakhs and Rs. 8.62 lakhs respectively. Thus the total cost of the contract of Messrs Texmaco was Rs. (21.54—17.52) = 4.02 lakhs higher than that of Messrs Marshall Sons, but there was a saving in foreign exchange component of Rs. (16.35—8.62) = Rs. 7.73 lakhs.

From the subsequent difficulties and complications that have followed, it appears that Messrs Texmaco were not sufficiently equipped to manufacture such gates, when the contract was sanctioned in their favour. The departmental technical specifications provided wheels and tracks of wrought steel and stainless steel respectively. These were changed to cast steel in both cases with a view to save some foreign exchange; this was done on the advice of the Central Water and Power Commission. The later experience, however, showed that they were not capable of manufacturing cast steel tracks of the requisite specification.

The delivery period as stipulated in the contract of Messrs Texmaco is 14 months for embedded parts and 18 months for gates and hoists, provided steel for embedded parts was made available within three months and for the gates within six months of the award of contract. There were delays in supply of steel but finally almost all the steel was supplied by September 1959 excepting a few minor items required for gates which were also received by them in December 1959. With a view to expedite the delivery of embedded parts (tracks and guides etc.) by Messrs Texmaco, several meetings were held between the project engineers and representatives of Messrs Texmaco and Messrs Voest with whose collaboration Messrs Texmaco are manufacturing these gates. During these meetings Messrs Texmaco had promised to fabricate all the embedded parts by December 1959 and commence erection in January 1960. However, during these months no progress was made by Messrs Texmaco on the fabrication of these parts and they were also unable to manufacture track in cast steel to the required

specifications. Due to this the construction of spillway blocks, which was ahead of schedule, had to be stopped at EL 730, because these blocks could not be raised unless the guides, tracks and other embedded parts were erected. It soon became evident from the experiments performed by Messrs Texmaco on the manufacture of cast steel tracks that they would not be able to manufacture these parts without any outside help. Arrangements were therefore made with Ordnance Factories at Calcutta to assist Messrs Texmaco in getting the tracks manufactured from them. The Ordnance factories readily came to their rescue and manufactured tracks of required specifications while other embedded parts were manufactured with some help from other factories in Calcutta. All these parts were therefore received and installed during May and June 1960 and the spillway blocks were raised upto E.L. 815 only and left there so that higher water level in reservoir may not endanger the safety of hemispherical bulk heads which were welded to the penstocks at their inlet ends because the delivery of penstock gates and hoists was uncertain.

Messrs Texmaco have also experienced difficulties in manufacturing forged wheels and wheel pins for the penstock gates. Arrangements were made with the Ordnance Factories at Calcutta to manufacture these.

With a view to expedite the supply of penstock gates, several meetings have been held between the project officers and representatives of Messrs Texmaco and eventually in August 1960, they gave the following programme*:—

1st gate	31-12-60
2nd gate	15-2-61
3rd gate	31-3-61
4th gate	15-5-61
5th gate	30-6-61

The grant of the work of supply of penstock gates to Messrs Texmaco thus involved considerable extra expenditure and anxiety to the project officers, delay in completion and risk to the safety of works.

4.11. As already stated in Chapter III on "Power Supply, Tariff and Financial Returns" that almost all the power has already been contracted to be supplied to various concerns. It is understood that the consumers concerned will be ready to take the power as per programme given below:—

	Consumer.	Demand to be supplied at 100% load factor.	Date by which consumer is expected to be ready for taking electricity.
(a)	Hindustan Aluminium Corporation .	50 MW	March 1962
(b)	For Railway electrification (at Karamnasa near Mughalsarai)	10.5 MW	March 1962
(c)	For Railway electrification (at Sonenagar) .	17.5 MW	June 1962

*Messrs Texmaco were not able even to stick to this programme. The first gate could only be erected in June 1961.

Consumer.	Demand to be supplied at 100% load factor.	Date by which consumer is expected to be ready for taking electricity.
(d) Madhya Pradesh Government . .	10.5 MW	(No intimation has been received from Madhya Pradesh Authorities regarding the date on which power will be taken.)
(e) Churk Cement Factory . . .	6.0 MW	January 1962.
(f) Other loads such as power for driving auxiliaries and local loads at Pipri, Robertsganj, etc.	2.0 MW	
	96.5 MW	
(g) Balance available for distribution .	3.5 MW	
TOTAL .	100.00 MW	

It will be seen that the major consumers will be ready to take power from March, 1962 onwards. The progress of the power project has to be scheduled to conform to the above requirement. There have been several difficulties in getting all the required materials for the transmission lines and the grid sub-stations. It is, however, hoped that the transmission lines will be ready in time to supply the power but there is every possibility of grid sub-stations not being ready. In such an eventuality it is understood that if complete sub-stations are not ready in time temporary arrangements for the distribution of power could be made, such arrangements are already in progress. All the five generating sets have since been tested, but the main consumers have not been able to make use of power. Temporary arrangements are being made to use about 25 MW at Allahabad, Mirzapur and Churk.

4.12. Further the Team notes that orders for equipment have been distributed among several manufacturers in four or five different countries. Such wide dispersal of supplies of highly intricate manufactured equipment may have been dictated by scarcity of certain foreign exchange but it has implied that the local design engineers of the project should recognise that much more than normal checking and following up is required of them to ensure that the work of the various manufacturers will be coordinated and their plant when assembled at site will function according to requirements. The Team had discussions on some of these features with the engineers on the project; the Team believes that they are ably dealing with these problems and gaining a very valuable experience.

CHAPTER V

COSTS OF PROJECT

5.1. As already mentioned in Chapter I on "History and Scope of Project" there have been three estimates for the construction of the Dam and Power House which have been sanctioned at different stages.

In all the three estimates the height of the Dam has remained the same with F.R.L. 880 and the same live storage capacity of 7·28 M.Ac. ft. has been provided. The scope of the Project has materially remained the same. As a matter of fact the firm power potential in 1956 Revised Estimate has somewhat decreased in comparison to 1947 Project. A comparative statement of the three estimates sub-headwise is given below :—

(Rs. in lakhs)

Sub-head.	1947 Project.	1952 Project.	1956 Project.
A—Preliminary	5.50	15.75	20.40
B—Land	72.57	71.47	144.87
C—Works	868·86	792.34	1765.00
K—Buildings	52.80	30.85	48.72
O—Miscellaneous	79.70	63.53	163.95
P—Maintenance	19.69	39.11	175.84
Q—Equipment	374.32	733.11	387.80
Special Tools and Plant . .	..	170.80	95.12
Loss on Stock and Suspense .	..	3.50	1.00
Establishment (Civil and Electrical Staff, including leave and Pension charges)	105.00	148.92	206.30
Tool and Plant	18.24	10.00	33.41
Receipts and recoveries under Capital Account	..	..	(—) 103.29
Audit and Accounts . . .	14.78	19.23	28.03
Capitalised abatement of Land Revenue	13.65	13.65	18.60
Total cost of generation	1625.11	2112.26	2985.75

5.2. It would appear that the main excess in 1956 Project estimate is under the Head C—Works. This is mainly due to the higher rates of concrete provided in 1956 estimate in comparison to those shown in the previous estimates. The rates in the previous estimates were based on analysis of cost of various component items under concrete, while the rates provided in 1956 estimate are based on the accepted tender of the Hindustan Construction Company Ltd., to whom the work of the construction of the dam has been let out. The question of excess under this head is dealt with in Chapter VII on "Agencies of Construction".

5.3. It is now anticipated by the Project Authorities that the construction of the dam and the Power House will cost about Rs. 3287.98 lakhs against Rs. 2985.75 lakhs provided in 1956 Project. A break-up of this amount sub-headwise alongwith figures of excesses and savings with reference to 1956 Project is given below :—

(Rs. in lakhs)

Sub-head.	Anticipated cost. (1960)	Saving and Excess with reference to 1956 Project.	
		Saving.	Excess.
A—Preliminary	20.40	..	..
B—Land.	244.87	..	100.00
C—Works	1882.72	..	117.72
K—Buildings	48.72	..	..
O—Miscellaneous	278.36	..	114.41
P—Maintenance	176.42	..	0.58
Q—Equipment	344.957	42.843	..
Special Tools & Plant . . .	64.956	30.164	..
Loss on Stock and Suspense . . .	1.00	..	..
Establishment (Civil and Electrical Staff including leave and pension charges) .	206.30	..	..
Tools and Plant	28.411	4.999	..
Receipts and recoveries under capital account	(—)58.355	..	44.935
Audit and Accounts	30.624	..	2.594
Capitalised batement of Land Revenue .	18.60	..	..
Total cost of generation: .	3287.983	78.006	380.239
Net Excess .	302.233 lakhs		

5.4. The reasons for excesses and savings are briefly discussed, below : —

Item No. 1

B—Land — Excess Rs. 100 lakhs

This increase is due to (*i*) extra rehabilitation grant now sanctioned in U.P. (*ii*) uprooting of stumps in the areas allotted to rehabilitated persons in U.P. (*iii*) anticipated excess of Rs. 42.84 lakhs in land compensation and rehabilitation in Madhya Pradesh.

Item No. 2

C—Works — Excess Rs. 117.72 lakhs

This excess is on the following items:—

(*i*) Excess due to increase in the rate of living index (assuming an increase of 20% of the base index of 1955) . . 23.00

The contract with Messrs Hindustan Construction Company Ltd. provides for adjustment in the rates of concrete according to the variation in the rate living index of semi-skilled and unskilled labour in Mirzapur district during the period of construction.

According to the terms of the contract, the cost of living index in Mirzapur district has to be fixed on the basis of economic survey to be carried out between January and March each year during the period of construction. It is understood that no such field survey has been carried out from year to year. It has now been mutually agreed to adopt the basis of living index at Kanpur.

(*ii*)	Excess due to increase in price of petrol and oil . . .	6 60
(*iii*)	Excess due to increase in price of steel	15.50
(*iv*)	Excess due to increase in price of explosives.	3 00

The rates in the contract with Messrs Hindustan Construction Company Ltd. are based on the price of steel, explosives, petrol and diesel oil as prevalent on 30-12-54. Any variation in price above 5 per cent over the prevalent price on 30-12-54 is to be adjusted.

(*v*)	Excess due to increase in price of cement	90.15

(a) The contract of Messrs Hindustan Construction Company Ltd. is based on the cost of cement at Rs. 52·50 per ton bulk supply and Rs. 60·000 per ton for supply of cement in bags. The price of cement in bulk and bags has since been raised by the State Trading Corporation which has caused this excess. All cement has now to be purchased through the S.T.C.

(b) Excess due to carriage of cement in bags in lieu of cement in bulk during breakdowns of bulk handling plant at cement Factory Churk.

(*v*)(*b*)	. . . . .	3 75
(*vi*)	Excess due to levy of electricity duty	7·00

According to the terms of contract with Messrs Hindustan Construction Company, the rate of electricity supplied to them for construction purposes was to be charged at anna 1 per KWH. The State Government have, however, decided that project will pay electricity duty also until 31st March 1959 after which this electricity duty has been waived taking Rihand Dam as a heavy industry. This excess could have been avoided if Rihand Dam had been taken as a heavy industry from the commencement.

(*vii*)	Excess due to increase in sales tax	5.50

The rate of sales tax on various commodities has been increased since the contract was let out to Hindustan Construction Co. Ltd.

(*viii*)	Excess due to increase in cost of permanent equipment due either to the delay in release of foreign exchange or due to award of contract to higher bidder to save foreign exchange and inclusion of cost of sixth set penstock gates and hoists, which has been found necessary in the interest of safety of works		10·8
		Total Excess .	165·30
Savings	(a) Saving due to reduction in cement content in concrete as a result of use of air entraining agent and flyash . .		22·00
	(b) Saving in quantity of concrete due to change in slope of Dam and lesser excavation		23·91
	(c) Other savings		1·67
		Total .	47·58
		Net Excess .	117·72

Item No. 3

O—Miscellaneous Excess 114.41

This is mainly due to the debit of Rs. 106 lakhs, the cost of Sone Bridge and road from Robertsganj to Pipri to the Project instead of charging it to normal road development programme of the State as was visualised in 1956 Project. As these assets form part of the road development programme of the State, their cost should normally be debited to that Department but the Rihand Dam Control Board decided in its 20th Meeting held on 30-10-1958 that the cost of Sone Bridge and road from Robertsganj to Pipri should remain charged to Rihand Project and that the revenue collected as toll tax on the bridge should be credited to the Rihand Project. Later, however, it has been decided by Government under G.O. No. 950SC/XXIII—IWA—119C/57 dated 20-1-1960 that the toll should be credited to the revenues of P.W.D. This appears to be an avoidable excess and will unnecessarily add to the cost of generation of electricity.

Item No. 4

P—Maintenance Excess 0.58

This is due to minor changes.

Item No. 5

Q—Equipment Saving 42.843

Due to lower costs as a result of competitive tendering from manufacturers of several countries.

Item No. 6

Special Tools and Plant Saving 30.164

This is due to the expectation of higher recoveries from the sale of the plant purchased. As no formal depreciation accounts have been kept for any of the plants it can not be said if this saving will be realised. The gross expenditure under the head is likely to be the same as in the Project.

Tools and Plants Saving Due to fewer costs Rs. 4.999

Item No. 7

Receipts and Recoveries under Capital Account Excess Rs. 44.935

This is mainly due to higher cost of generation. The main consumer is Hindustan Construction Company who are the contractors for the Dam. According to the terms of contract they have to be charged a fixed rate of one anna per unit whatever may be the actual cost of generation. The actual average cost of generation is about 0·10 nP. per unit.

Item No. 8

Audit and Accounts Excess (Due to increase in capital cost of work.) Rs. 2.594

5.5 The 1947 estimate did not provide for cost of Transmission, Transformation and Distribution System.

As the project is approaching completion, the indications are that the excesses will probably be less as there are savings on establishment and maintenance etc.

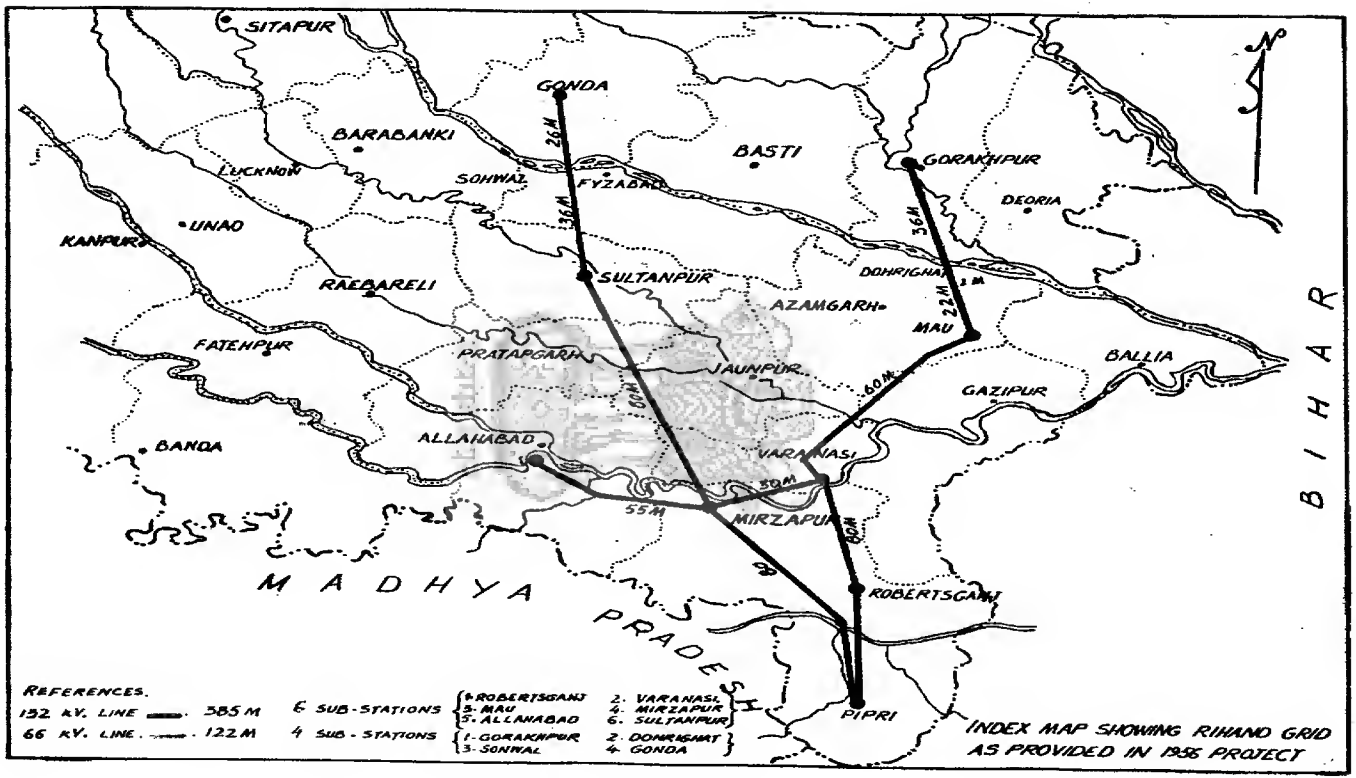
The 1952 estimate provided for Rs. 14.09 crores for cost of Transmission, Transformation and Distribution System.

The 1956 estimate provided for Rs. 959.81 lakhs for Transmission and Transformation and Rs. 659.57 lakhs for Distribution System. These estimates provided for Transmission and Distribution System both on South and North of Ganga.

5.6 As now the whole of the energy generated at Rihand is proposed to be supplied to industries and other consumers on South of the Ganga, the 1960 estimated cost is expected to be Rs. 350.934 lakhs only. It may be mentioned that most of the power will be sold at Pipri power house itself. The interconnecting grid on the North of the Ganga is proposed to be constructed under a separate estimate.

Two plans showing 1956 and 1960 grids are placed opposite.

5.7 There is no Financial Adviser attached to the project. There is no Central Accounts Organisation either. The expenditure incurred on the Project is booked by the Accountant General, Uttar Pradesh. A resident audit officer was, however, appointed in December 1958 at the site to conduct concurrent post audit, but this cell has since been removed by the Accountant General U.P. as it was not proving to be very helpful or useful. No difficulties have, however, been experienced on this account and all figures of expenditure under various heads of the project have been well kept in a Project Register by a cost accounting cell attached to the Superintending Engineer (Civil). This accounting cell is also doing useful work in preparing detailed analysis of actual costs of various items of work which should be very useful for reference on other projects in future.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DOHRIGHAT
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JAUNPUR
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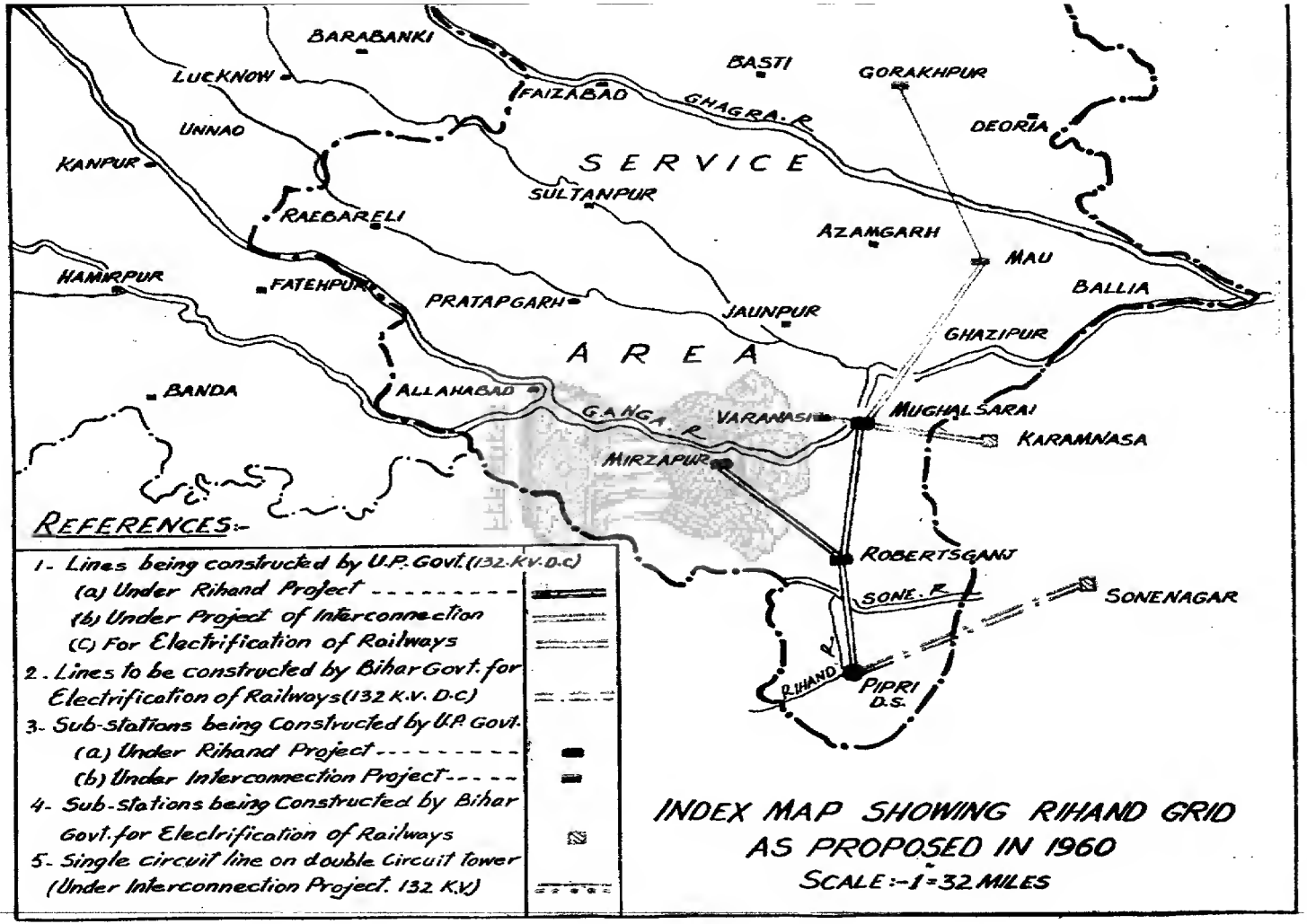
REFERENCES.
132 kV. LINE ——— 385 M
66 kV. LINE. — — — 122 M
6 SUB-STATIONS 1. ROBERTSGANJ 2. VARANASI. 3. MAU 4. MIRZAPUR 5. ALLAHABAD 6. SULTANPUR
4 SUB-STATIONS 1. GORAKHPUR 2. DOHRIGHAT 3. SOHWAL 4. GONDA
INDEX MAP SHOWING RIHAND GRID AS PROVIDED IN 1956 PROJECT



INDEX MAP SHOWING RIHAND GRID AS PROPOSED IN 1960

SCALE :- 1 = 32 MILES

CHAPTER VI
IRRIGATION ASPECT

6.1. The Rihand Project is mainly a hydro-electric project but in all the three projects prepared at different stages, indirect irrigation benefits have been shown as accruing from the project. In 1956 project it has been shown that 14 lakh acres will be irrigated from tube-wells in U.P. and 5 lakh acres of flow irrigation in Bihar. Additional foodgrains have been shown as 2 lakhs tons per year. The irrigation facilities were to be provided in the eastern and south-eastern districts of U.P. where there are high spring levels. It was visualised to provide tube-wells which could be provided with cheap electric power from Rihand Project. It is, however, now seen that almost all the power from Rihand Project will be utilised in close vicinity of Rihand for development of industries and for railways. As already explained in Chapter II on "Hydrology and Power potential", very little power will be available for miscellaneous uses or lift irrigation. The irrigation benefits which were assumed in the Project in U.P. areas may not therefore be directly realised, but as a result of inter-locking of existing thermal stations at Mau, Gorakhpur and Sohwal on north of Ganga with Rihand grid, more power units will be generated by working the thermal station as based load and by taking peaks on the Rihand Power Station. This will indirectly help the tube-well irrigation in that area.

6.2 After the completion of the Rihand Dam a regulated discharge of about 6,000 cusecs will be let down from the Power House throughout the year in the Rihand river which is a tributary of the river Sone. This water will be available for diversion in the Sone canal system at Dehri in Bihar which is about 100 miles downstream from Rihand Dam. In the non-monsoon season this discharge will be flowing in the wide bed of the river Sone. During that season and more so in the hot weather months there are likely to be some losses by evaporations and absorption in this discharge before it reaches Dehri. It would be desirable to make observations of such losses so that a correct appreciation of discharge that will be available at Dehri can be made.

6.3 A new barrage has been sanctioned to be constructed at a distance of about 5 miles upstream of the present anicut at Dehri. It is proposed to provide link canals from this barrage to the two existing irrigation canals on the right and left banks and two high level canals are also being considered for irrigating some new areas in the upper reaches. It is also proposed to extend irrigation on the existing Sone canal system. The additional areas which are expected to be irrigated after the construction of the Sone Barrage will approximately be as under :—

I. Additional areas in present Sone canal system due to remodelling.	
(*I*) Main eastern canal	0.68 lakh acres.
(*II*) Main western canal	2.40 ,,
	3.08 lakh acres.
II. Western High Level canal.	1.26 ,,
	4.34 lakh acres.

The proposal for the Eastern high level canal has not taken a final shape.

6.4 The question of utilising the regulated discharge, which will be available from Rihand Dam after its completion, and sharing of part cost of Rihand Dam by Bihar is being considered between the two States.

CHAPTER VII

AGENCIES OF CONSTRUCTION

7.1 As already mentioned in Chapter V on 'Costs of Project', the main reason for the excess in 1956 estimate is due to the provision of higher rates of concrete for the dam in that estimate under 'C'—Works in comparison to those provided in 1947 and 1952 estimates. The excess in 1956 estimate under 'C'—Works amounts to Rs. 897 lakhs in comparison to 1947 estimate. The rates provided in 1956 estimate are based on the accepted tender of Messrs Hindustan Construction Company Limited to whom the work of the construction of the dam was let out in 1955. When 1947 estimate was prepared a rate analysis for the various components of the bulk concrete was prepared in detail and the unit rate provided in that estimate was Rs. 75.37 per 100 cft. This rate was based on the use of 12½ bags of cement per 100 cft. of bulk concrete and it would have been Rs. 107.50 if adjusted for the higher cost of cement prevalent at the time of construction of the project (*vide statement* 7·1). As already stated the work on the construction of this scheme was temporarily suspended in 1949 and when in October 1951 it was decided to resume the work a fresh project estimate was prepared in accordance with the general designs and specifications prepared by Messrs International Engineering Company of U.S.A. A revised analysis of rate for mass concrete was worked out taking into account the conditions prevailing at the time. The rate provided in the 1952 estimate was Rs. 76·50 per 100 cft. of mass concrete but this was exclusive of depreciation charges and maintenance and operation of the construction plant for which a separate provision was made in the estimate. This rate of Rs. 76.50 was based on the use of 12 bags of cement per 100 cft. of concrete. The provision for depreciation of plant and maintenance and operation of the same works out to Rs. 23 per 100 cft. The overall unit rate of bulk concrete thus came to Rs. 99.50 per 100 cft. This rate would have been Rs. 125.63 per 100 cft. if adjusted for the higher cost of cement prevalent at the time of actual construction of the dam (*vide statement* 7·1).

7.2 It may be mentioned that the rate analysis for the various components of the bulk concrete both in 1947 and 1952 estimates was based on the data then available which the Project Authorities have stated was inadequate and meagre.

The work on the preparation of the Master Plan for the construction of the dam, power house and appurtenant works was started on the basis of this estimate and completed in early 1954. The question then arose as to whether the work should be done departmentally or on contract. It appears that the Ministry of Irrigation and Power suggested that the work should be done departmentally in the accepted sense of the word. Subsequently the Government of U.P. decided to invite global tenders for the construction of the dam, power house and appurtenant works. After the receipt of the tenders, the question as to whether the work should be done departmentally or the contract may be awarded to the lowest tenderer, (Messrs Hindustan Construction) was put up to the Technical Advisory Committee of the Rihand Control Board. The tender of the Messrs Hindustan Construction was accepted on the advice of the Committee in early 1955.

7.3. The unit rate for bulk concrete quoted by Messrs Hindustan Construction Company is Rs. 204 per 100 cft. This rate is on the basis of use of only 11 bags of cement per 100 cft. concrete and the cement is to be supplied by Government at the bulk rate of Rs. 52.50 per ton at the factory. Any increase in the cost of cement is to be borne by Government. As there has been considerable increase in the cost of cement the excess on the project due to this reason is expected to be Rs. 90.15 lakhs.

The above rate of Rs. 204 per 100 cft. of bulk concrete is exclusive of the charges for cooling of concrete for which a separate lump sum amount of Rs. 28.73 lakhs is provided in the tender. This amount is for cooling concrete up to 40 M. cft. and a rate of Rs. 3.50 per 100 cft. is provided for cooling of additional concrete over 40 M. cft.

Besides there are the following additional clauses regarding this rate.

(i) The electric energy is to be supplied by Government at one anna per unit whatever may be the cost of generation. As already mentioned in Chapter V on 'Costs of Project' the cost of Generation Power Houses is about 0.10 nP. per unit. The extra charge will have to be borne by the Government.

(ii) The rate is subject to adjustment on account of increase or decrease in the cost of living index of semi-skilled and unskilled labour with reference to the base index of 1955. As already mentioned in Chapter V on 'Costs of Project' an additional amount of about Rs. 23.0 lakhs will have to be paid on this account.

(iii) The unit rates tendered by the contractors are based on the prices of explosives, steel, diesel oil and petrol prevalent on 30th December, 1954. The contractors have to be compensated for increase in such prices. It is expected that the extra cost on this account will be about Rs. 25.1 lakhs.

(iv) The rates tendered by the contractor are based on the use of 11 cwt. of cement per 100 cft. of concrete; if the contractor is required to use any different quantity of cement, the rate is subject to adjustment upward or downward on the basis of such variation in cement content. The actual quantity of cement used, the bulk concrete as reported by the Project Authorities is only 9 cft. per 100 cft. of concrete. This saving has been effected without affecting the strength by the use of concrete of fly-ash and the air entraining agent. After allowing for the cost of these materials, the net saving is about Rs. 8.14 per 100 cft. of concrete. This saving will balance the extra cost on items (*ii*) and (*iii*) above (*vide statement* 7.1).

7.4 The tender was approved in early 1955 and the work had been completed by beginning of 1962. The completion of the work has thus taken nearly 7 years.

7.5 No analysis of bulk rate of concrete is shown in 1956 revised estimate as was done in 1947 and 1952 estimates. This estimate is based on the rates quoted by Messrs Hindustan Construction Company.

A comparative rate analysis for mass concrete provided in the three estimates has been prepared by the Team (*vide statement No.* 7.1). It would be seen that the rate tendered by the contractors and as provided in 1956

estimate is very much higher than those provided in the previous estimates. It has been stated by the Project Authorities that a fresh analysis of the rate of bulk concrete was prepared for departmental execution and it was seen that the departmental construction would not be cheaper than through the contractors.

7.6 According to the terms of the contract the Government has to make advance payments towards the cost of the following items during constructions :—

(i) Construction plant and equipment whether purchased in India or abroad, its transport and installation at site.

(ii) Cement and other materials required by the contractor.

(iii) Salary and other cost of non-India technical personnel if any required.

(iv) Construction of store-houses and buildings required for the construction personnel at the site of the work.

(v) Construction of approach roads in works-area. All foreign exchange supply of steel and cement have to be arranged by the Government.

The contract provides for the foreign exchange to the maximum extent of 5 million United States dollars for the purchase of construction plant and equipment including spare parts, materials and supplies and for their transportation and insurance to India and for services through suppliers in the erection, installation and final operation of the construction plant and equipment.

For this work the Contractors have obtained the plant and equipment from various sources. The approximate figures of the cost of plant obtained by the contractors through various sources are given below :—

(i) Equipment purchased directly by the contractors under T. C. M. aid.	Rs.	2,36,51,285
(ii) Equipment procured by the department under T.C.M. aid and handed over to the contractors.		9,80,400
(iii) Equipment purchased by the contractors in India.		8,62,044
(iv) Equipment brought by the contractors from Vaitarna works.		52,50,000
	TOTAL	3,07,43,729

These figures are exclusive of the cost of spares etc. The details of the equipment obtained through various sources are given in *Appendices IV, V, VI and VII.* The quantity of concrete to be done is about 60 M. cft. The cost of plant required works out to about Rs. 51 per 100 cft. of concrete.

In this particular contract there is a provision for taking over from the contractors, the cableway equipment batching and mixing plant and cooling plant after the completion of work at their depreciated value which

will be taken as 30 per cent of the initial cost of equipment delivered at site of work excluding cost of erection, testing, foundations etc. The details of the equipment along with the depreciated cost are given in *Appendix VIII*. As the work is approaching completion, it will be advisable to supply the details of the equipment to the other States in case any of them needs the same for any project, provided the U.P. Government does not need it for any of its projects.

7.7 Considering the element of contractor's profit and payment of the income-tax on the same by them and the likelihood of their writing off of most of the plant costing over Rs. three crores, though there will be considerable residual value left, it is not unlikely that if the work of this nature can be done departmentally in an efficient manner, there should be a saving of about Rs. 40 or so per 100 cft. of concrete on a rate of Rs. 204 per 100 cft. tendered by the contractor.

When such large works requiring a number of years for completion are put to tender, the contractors provide for all sorts of contingencies which may or may not arise. Besides, the contractors' rates usually include write-off of most of the plant and machinery although they have considerable residual value in the end. Contractors have to allow for fair margin of profit and payment of income-tax etc. Due to these reasons their rates are naturally high. The tenders are usually hedged in by many special clauses which contractors put in to safeguard their interests. Besides, most of the services like water-supply, electricity and important materials like steel, cement, etc. have usually to be arranged for by the Government. Foreign exchange and advance payments for machinery, colonies, *etc.* have also to be supplied by the Government.

In view of all these factors it would seem to be advisable that works of such magnitude involving use of considerable machinery and plant and extending over a number of years should be executed departmentally using Government machinery and employing small contractors or piece-workers. Of course, in case of departmental execution there are many difficulties such as delay in procurement of machinery and spare parts, grant of foreign exchange, getting sanctions to the necessary staff and in fixing the salary of the people working on the machinery etc. Besides, there has been a growing tendency towards curtailment of the powers of the Chief Engineer specially after the separation of Chief Engineer's post from that of the Secretary to Government. If these difficulties can be successfully overcome there should be considerable saving in departmental execution of such large projects.

7.8 The Team feels that it would be profitable if a Committee consisting of technical, financial and administrative experts is appointed to suggest ways and means to overcome the difficulties which are often expressed by the Chief Engineers concerned and to frame rules and procedures for implementing this recommendation.

STATEMENT 7.1

RATE OF MASS CONCRETE PROVIDED IN THE THREE ESTIMATES—RIHAND DAM PROJECT (Power Generation)

Estimates	Rate in Rs. per unit (100 cft.)	Quantity of cement required per unit (in bags cwts.)	Cost of cement				Aggregate		Charges for mixing, transporting and laying concrete. (Rs. per unit)	Depreciation cost of maintenance and operation of plant (Rs. per unit)	Charges for cooling of concrete (Rs. per unit)	Extra charges due to high rate of cement (Rs. per unit)	Extra charges for the supply of electricity (Rs. per unit)	Misc. charges (Rs. per unit)	Overall charges (Rs. per unit)
			Rs. per ton at factory	Freight (in Rs. per ton)	Total cost (in Rs. per ton) (4+5)	Cost of cement required for one unit of mass concrete.	Coarse (90 cft.) cost in Rs.	Fine (45 cft.) cost in Rs.							
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1947 (a)	75.37	12½	45.00	10.00	55.00	34.37	9.00 (b)	10.00 (c)	21.00 (d)	(e)	..	31.91 (p)	..	1.25	107.53
1952 (f)	76.50	12	52.50	10.00	62.50	37.50	12.63 (g)	9.00 (h)	17.37 (i)	23.00 (j)	..	26.13 (q)	..	..	125.63
1956 (k) (Revised)	204.00	11	52.50	12.50	65.00	35.75	..	..	..	..	4.79 (l)	23.96 (m) likely to increase	3.40 (n)	..	236.15 (o)

NOTES—(a) See page 152, chapter 39, 1947 Estimates.

(b) @ Rs. 10.00 per 100 cft.

(c) @ Rs. 22.00 per 100 cft.

(d) Inclusive of depreciation.

(e) Included in column 10.

(f) See page 45, Appendix 4, 1952 Estimate.

(g) @ Rs. 14.00 per 100 cft.

(h) @Rs. 20.00 per 100 cft.

(i) Exclusive of depreciation, maintenance and operation of plant.

(j) Depreciation of special tools & plant and construction power = Rs. 23.00 per unit *vide* page 34 of 1956 Revised estimate.

(k) See schedule of quantities (Item 40) and para 34 of the Contract for construction of Dam, Power House, and Appurtenant works of Hindustan Construction Company.

(l) Lump sum provision = Rs. 28,75,000 — Item 60 of schedule of quantities of the contract of Hindustan Construction Company. Total quantity of concrete=6,00,000 units—Item 60(a) and (b) of the schedule of quantities of the Contract. ∴ Rate per unit= Rs. 28,75,000, ÷ 6,00,000= Rs. 4.79.

(m) Rate for bulk supply of cement at factory as reported by project Authorities = Rs. 96.06 per ton.
∴ Reimbursement from project costs=Rs. 96.06—Rs. 52·50=Rs. 43.56 per ton.∴ Rate per unit (11 bags)=Rs. $\frac{43.56 \times 11}{20}$=Rs.23.96.

(n) Expenditure on H. T. and Lt. Lines=Rs. 12.69 lakhs (Appendix 13, pages 113-114—Revised 1956 Estimates) Maintenance charges —Power Plant = Rs. 110·77 lakhs (Appendix 22, page 138, Revised 1956 Estimates). Special Tools and Plant (less resale value) = $\frac{\text{Rs. } 40{\cdot}50 \text{ lakhs}}{\text{Rs. } 163{\cdot}96}$ (Appendix 19, pages 129 — 130 — Revised 1956 Estimates). Total number of units to be generated = 164 MKWH (Appendix 22, page 138, Revised 1956 Estimates). ∴ Rate per KWH (1 unit)=Rs. 163 96 lakhs÷164 MKWH=00.10 nP. Power actully used per unit of concrete works out to 85 KWH as reported by the projects authorities. The power has to be supplied to the contractors at the unit rate of 0·06 nP. ∴ The extra debit to the rate of concrete at 0.04 nP. (0.10—0.06) per KWH = 85×0.04 nP. = Rs. 3.40 per 100 cft. ∴ Debit to Project @ 0 04 nP. (10—6) per KWH = 184 × 4 nP. = Rs. 7.36 nP.

(o) This rate does not include the extra amount that have to be paid to the contractors on account of rise in cost of living index, steel, diesel oil, petrol, and explosives. These amount to Rs. (23.0 +6.00+15.50+3.00) = 48.1 lakhs. The extra charge on account of this, per unit of concrete will be $\frac{\text{Rs. } 48.1 \text{ lakhs}}{60{,}00{,}000 \text{ units}}$ = 8.01 per unit. There is however saving due to reduction in cement content in concrete due to use of air entraining agent and flyash which have to be supplied free of cost to the cotractors. As reported by the Project Authorities the saving due to use of fly-ash and air entraining agent after allowing for their cost Rs.8.14 per unit of concrete. As both balance they are not separately accounted for in this rate.

(p) Adjustment in rate due to higher cost of cement at the time of actual execution of project = $\frac{12.5}{20}$(96.06—45)=0.625×51.06=31.91% cft. of concrete.

(q) Adjustment in rate due to higher cost of cement at the time of actual on execution of project = $\frac{12}{20}$(96.06—52.50)=0.6% 43.56=26.13.

SUMMARY

I. History and scope of Project

This is mainly a hydro-electric project. Three estimates have been sanctioned for this project at different times. These are :—

Year of preparation.	The estimated cost for power generation.
	Rs. (crores.)
1947	16.25
1952	21.12
1956 (Revised)	29.86
1960 (Anticipated)	32.88

The power potential of 1956 (Revised) project is as under:—

Firm power potential	1,05,000 KW
Units generated	912 MKWH
Installed capacity	2,50,000 KW (consisting of 5 sets of 50,000 KW each and room for 6th set of 50,000 KW at a subsequent date).

II. Hydrology and Power Potential

The Rihand river above the dam site drains an area of 5148 sq. miles with an average rainfall of about 56 inches per annum. This river is a tributary of the river Sone.

There was no gauge discharge site on the river Rihand prior to the commencement of the project. One gauge discharge site existed on the river Sone at Dehri-on-Sone about 100 miles downstream of the dam site. The run-off of the river Rihand was worked out on the basis of study of the record of run-off of the river Sone in conjunction with the study of the annual rainfall over the catchment. On this basis the run-off was worked out as 7.270 M.Ac. cft.

A gauge discharge site was established at Pipri and actual discharges have been taken from 1945-46 onwards. The average annual run-off studies have been made as more and more discharge data has become

available. The average annual run-off as shown in the three projects is as under :—

Year of preparation.	Average annual run-off.
1947 Project	7.270 M.Ac. ft.
1952 Project	6.060 "
1956 (Revised) Project	5.138 "

The power potential has naturally varied on this account. The power potential adopted in 1956 project is 1,05,000 KW at 100% load factor. The latest studies have shown that there will be short fall in this power in certain years of drought.

There is a proposal for constructing a thermal station of 2,50,000 KW in this region for utilising the coal resources nearby. With the construction of the thermal station, it should be possible to firm up the hydro-energy to the extent assumed in 1956 project in years of drought.

Almost all the firm power from Rihand Project is already booked and is expected to be utilized by 1965-66.

There is a scope for further development of hydro-power on the Rihand river. There is a suitable site for a low lifting dam about 20 miles downstream of Rihand at Obra where about 50,000 KW of firm power can be developed. This proposal is a promising one ; it would help to improve the overall economy of Rihand Hydro-electric power development.

III. Power Supply, Tariff and Financial Returns

The cost of generation as worked out in 1956 (Revised) Project amounts to 2.32 nP. per KWH on the basis of 1% profit on capital cost of generating assets and 1.99 nP. per KWH exclusive of this profit.

The above cost of generation has not been worked out in accordance with the provisions of the Electricity (Supply) Act 1948. The operation and maintenance, depreciation, and interest charges have been worked out only on the part of the "original cost" of the project, instead of on the entire 'original cost'. The 'original cost' is the cost of building generating assets at the commencement of operation and this includes the capital cost of work and cumulative interest during the period of construction. The 'original cost' of the project as per 1956 (Revised) Estimate amounts to Rs. 3591.75 lakhs of which Rs. 2985.75 lakhs is for works and Rs. 606.00 lakhs for cumulative interest during period of construction.

The operation and maintenance charges have been calculated by the Project Authorities on Rs. 2201.00 lakhs, depreciation charges on Rs. 2127.60 lakhs and interest on Rs. 2985.75 lakhs only.

The operation and maintenance charges amount to about 0·5% of the original cost. This estimate is very low. Normally such charges amount to 1.5% of the original cost. However, the Team considers that such charges would not be less than 0·75% on the original cost of civil works and

2% on the original cost of electrical works. On this basis these charges would amount to 1.01% of the original cost of Rihand Project.

The annual depreciation charges on different categories of plant have been estimated by the Project Authorities in 1956 estimate in an *ad hoc* manner and not on any recognised basis. It is necessary to estimate the depreciation charges in accordance with the method outlined in the Seventh Schedule of the Electricity (Supply) Act of 1948. The depreciation charges according to this method would amount to Rs. 42 lakhs against Rs. 26.05 lakhs provided in the estimate.

The interest charges at 4·5% on the original cost amount to Rs. 161.63 lakhs against Rs. 134.36 lakhs provided in the estimate. The Team has suggested provision of 0·5% on the original cost for contingencies and general reserves on the basis of the Electricity (Supply) Act; this amounts to Rs. 17.96 lakhs. The project estimate provides 1% for profit on the capital cost of works; this amounts to Rs. 29.86 lakhs.

On the basis of the above provisions, the cost of generation for 1956 (Revised) estimate works out to Rs. 2.85 nP. per KWH.

About half of the total energy available at Rihand has been contracted to be sold at 1.997717 nP. to Hindustan Aluminium Company which is much below the cost of generation.

The present estimated cost of the Project is Rs. 3287.983 lakhs and the cumulative interest during the period of construction would be Rs. 667.401 lakhs. The original cost of this project would now be Rs. 3955.384 lakhs. The cost of generation on the basis of this amount works out to 3.16 nP. per KWH. As about half the energy has been contracted to be sold to Hindustan Aluminium Company at 1.997717 nP. per KWH, the remaining energy will have to be sold at not less than 4.25 nP. per KWH if financial losses are to be avoided. This is relatively a high cost for hydro-power.

In the latest calculations sent by the Project Authorities, the annual depreciation has been calculated according to the Seventh Schedule of the Electricity (Supply) Act 1948. They have adopted the sinking-fund method. It is noticed, however, that the provisions cover only incremental deposits according to this method. No provision has been made for interest on accumulated balances in the reserve as required by Section 68 sub-section 2.

The Electricity (Supply) Act 1948 provides two methods for calculating annual depreciation charges. One is a straight-line method and the other is the sinking-fund method. In both the methods, however, a depreciation reserve equal to 90% of the original cost of generating assets has to be recovered in full from the consumers. As different view points are often expressed on this question and no uniform basis is followed in preparation of various hydro-electric projects, it would be profitable if the Irrigation and Power Ministry considers appointing an expert committee to standardise and recommend practices on this aspect of utility management.

The Project Authorities had originally estimated a net yield of 5.5% from the working of the project. The latest financial forecast based on up to date cost as revised in 1960 shows an ultimate net yield of 7.4%.

It will not be possible to realise either of these forecasts, even if the balance of power now available for other purposes is sold at the generation cost of 4.25 nP. per unit. The net yield even then would only be about 4.5% which would be barely sufficient to meet interest on borrowed capital after providing 0·5% for contingencies and general reserves.

In addition to the operation and maintenance, depreciation and interest charges and provision for contingencies and general reserve, various other costs have actually to be met which are not exactly covered by these items. A working capital is necessary for the purposes of operation and interest has to be provided for procuring it. Plant and workers must be insured against accidents. There may be damages due to floods and hurricanes and losses due to strikes and mal-operation. Plant replacement will certainly cost more than current depreciation provisions. There should therefore be some reserve to meet such expenses and to avoid fluctuations in tariffs for power sales or surcharges that would otherwise become necessary as the Electricity Boards are not to operate at a loss. The Team suggest that a special provision of at least 1% of the original cost should be made when recurring costs are reckoned for making tariffs.

IV. Construction Features and Construction Programme

Before the commencement of the construction of the Dam the question arose whether the Dam should be constructed in rubble masonry or in concrete. The Chief Engineer favoured the construction in concrete on the score of three factors, namely, (*i*) safety of the Dam as the maximum allowable principle stress for rubble masonry cannot safely be taken than 250 lbs. per sq. inch, as against 350 lbs. per sq. inch or more for concrete; (*ii*) extra cost of construction of the Dam in stone masonry. He estimated that it would cost Rs. 3.5 crores more; and (*iii*) longer time required for construction in rubble masonry. He estimated that dam in rubble masonry will take 6 years more than the concrete dam.

A committee of experts was appointed to report on this question. This committee favoured the construction in rubble masonry on the score of (*i*) safety; (*ii*) much lesser cost of construction in rubble masonry than in concrete. The committee estimated that there will be a saving of Rs. 1.9 crores if the dam is constructed in rubble masonry; and (*iii*) giving greater scope of employment both for skilled and unskilled labour than that for the concrete construction. The Committee stated that the rubble masonry dam would not take more than 9 months extra as against 6 years given by the Chief Engineer. As U.P. Government did not want to take any risk it was finally decided to construct the Rihand Dam in concrete.

Since 1954 when this decision was taken, considerable further data and experience has become available from the dams under construction specially Koyna, Nagarjunasagar and Rihand Dam. Indications are that for dams up to about 370 ft. height, if conditions like availability of suitable stone for rubble masonry, skilled masons and other labour etc. are favourable, the rubble masonry construction would be cheaper and equally safe as the concrete construction.

It would be useful if a comprehensive study of this general question of cement concrete versus masonry is made specially as the construction work on the three dams is much advanced now and more factual data of cost and rate of progress etc. will be available.

The progress on concrete has been affected to a certain extent by delay in supply of penstock gates by Messrs Texmaco who were given this work with a view to save foreign exchange of Rs. 7.73 lakhs. Further as they were not fully equipped to undertake such a work there have been considerable delays in supply of the various parts of the gates. This has involved considerable anxiety to the project officers and a certain amount of risk to the safety of the works.

V. Costs of Project

There have been a number of revisions of the estimated cost of the project as indicated earlier. The present anticipated cost on the basis of excesses and savings that can be foreseen is Rs. 3287.983 lakhs. This would involve an excess of Rs. 302.233 lakhs over the 1956 sanctioned estimate. The major excesses are on :—

(1) B—Land	Rs. 100	lakhs due to extra rehabilitation grant etc.
(2) C—Works	Rs. 90	lakhs due to the higher rate of cement at which it is supplied by the State Trading Corporation as all cement is now to be purchased through that organisation.
(3) O—Miscellaneous	Rs. 106	lakhs due to the cost of the Sone bridge and road from Robertsganj to Pipri being now charged to the project instead of charging it to the normal road development programme of the State as was visualised in 1956 project.

The other smaller excesses and savings balance themselves.

There is no Financial Adviser attached to the project and there is no central accounts organisation either. No difficulties have, however, been experienced in this system on this account and all figures of expenditure under various heads of the project have been well kept in the project register by cost accounting cell attached to the Superintending Engineer (Civil).

VI. Irrigation Aspect

The project visualises indirect irrigation benefits of 14 lakh acres of tube-well irrigation in U.P. and 5 lakh acres of flow irrigation in Bihar.

As almost all the power will now be utilised in close vicinity of Rihand for development of industries and by railways there will be very little power available from Rihand Project direct for use for lift irrigation in U.P. The irrigation benefits which were assumed in the Project in U.P. area may not therefore be directly realised but as a result of inter-locking of existing thermal stations at Mau, Gorakhpur and Sohwal on north of Ganga with Rihand grid, more power units will be generated by working the thermal stations as base-load and by taking peak on the Rihand power station. This will indirectly help the tubewell irrigation in that area.

The question of utilising the regulated discharge from Rihand Dam and sharing a part cost of the same by Bihar is being considered by the two States. The extra irrigation visualised to be done in Bihar at present is about 4.3 lakh acres.

VII. Agencies of construction

The main reason for the excess in 1956 estimate is due to the provision of a higher rate for concrete for the dam in that estimate in comparison to that provided in 1947 and 1952 estimates. The rate for bulk concrete provided in 1947 estimate was Rs. 75.37 per 100 cft. and that in 1952 estimate Rs. 99.50 per 100 cft. It may be mentioned that the rate analysis for the various components of the bulk concrete both in 1947 and 1952 estimates was based on the data then available which the Project Authorities have stated was inadequate and meagre.

The rate provided for bulk concrete in 1956 estimate is Rs. 204 per 100 cft. This is based on the rate tendered by the Messrs Hindustan Construction Company to whom the work of construction of the dam has been allotted. This rate is exclusive of the charges for cooling of concrete and will be subject to increase due to (*i*) increase in the cost of living index; (*ii*) rise in prices of explosives, steel, diesel oil, and petrol; (*iii*) higher cost of generation of electricity which is to be supplied by the Government on a fixed rate of one anna per unit to the contractor; and (*iv*) higher cost of cement which is to be supplied to the contractor at a fixed rate of Rs. 52.50 per ton in bulk at the factory.

Before the commencement of the work the Ministry of Irrigation and Power suggested that the work should be done departmentally in the accepted sense of the word. However, as the Project Authorities considered that the departmental construction would not be any cheaper than through the contractors the question was referred to the Technical Advisory Committee of the Rihand Control Board which recommended that the work may be let out on contract to the lowest tenderers—Messrs Hindustan Construction Company Ltd. This recommendation was accepted by the Rihand Dam Control Board.

When such large works requiring a number of years for completion are put to tender the contractors provide for all sorts of contingencies which may or may not arise. Besides, the contractors' rates usually include write-off of most of the plant and machinery purchased for works, although they have considerable residual value in the end. The contractors have to allow for a fair margin of profit and payment of income-tax etc. Due to these reasons their rates are naturally high. The tenders are usually hedged in by many clauses which contractor's put into safeguard their interests. Besides, most of the services like water supply, electricity and important materials like steel, cement etc. have usually to be arranged for by the Government. All foreign exchange and advance payment for machinery, colonies, *etc.* have to be supplied by the Government. In view of all these factors the Team is of the view that works of such magnitude involving use of considerable machinery and plant and extending over a number of years can with advantage be executed departmentally using Government machinery and employing small contractors or piece-workers.

The Team feels that it would be profitable if the Irrigation and Power Ministry considers appointing a committee of technical, financial and administrative experts to suggest ways and means to overcome the difficulties which are often felt by the Chief Engineers in departmental execution of such works and to frame rules and procedures for implementing this recommendation.


सत्यमेव जयते

APPENDICES

I. Rihand Project—Salient Features.

II. Calculation of annual depreciation in accordance with Electricity (Supply) Act 1948 as supplied by the Project Authorities.

III. Details of working expenses as supplied by the Project Authorities.

IV. Equipment purchased directly by the contractors under T.C.M. aid as supplied by the Project Authorities.

V. Equipment procured by the Department under T.C.M. aid and handed over to the Contractor as supplied by Project Authorities.

VI. Equipment purchased by the contractor in India as supplied by the Project Authorities.

VII. Equipment brought by the Contractor from Vaitarna Works as supplied by Project Authorities.

VIII. List of equipment which the Government will take back from Messrs Hindustan Construction Company under terms of contract (Clause 33.1).


सत्यमेव जयते

APPENDIX I

Rihand project—Salient Features

Location

On the Rihand river, 28.7 miles south of the confluence with the river Sone, near village Pipri in Mirzapur District.

Drainage Basin Characteristics

Catchment Area	5,148 sq. miles.
Average annual precipitation (1903-1955)	56.3 inches.
Estimated average annual run-off (1903-1955)	18.7 inches.

Stream Flow Data

Maximum recorded flow at Badura discharge site on 12-8-50	4,60,000 cusecs.
Minimum recorded flow at Badura site on 1 to 6-6-1947	43 cusecs.
Maximum probable flood (Spillway design flood)	6,10,000 cusecs.
Maximum possible flood	8,41,000 cusecs.
Estimated average annual run-off (1903-1955)	5,138,000 acre feet.

Reservoir

Area submerged at full tank level (Elevation 880)	180 sq. miles.
Gross storage capacity at EL. 880	86,00,000 acre ft.
Live storage capacity (between EL.880 and 775)	72,80,000 acre ft.
Dead storage at EL.775	13,20,000 acre ft.
Full reservoir Elevation	880.00
Maximum probable reservoir EL.	886.00
Maximum possible reservoir Elevation	890.82
Dead storage Elevation	775.00
Average tail water Elevation	632.00

Dam

Type	Concrete Gravity dam.
Thickness of top	24 ft.
Thickness of bottom (non-overflow section maximum)	227 ft.
Top Elevation (Road level)	894.50
Crest Elevation spillway	852.00
Expected deepest foundation level	600.00
Maximum height above deepest foundation	300 ft.
Height of dam above lowest point in river bed	271 ft.

Length of dam	3,254 ft.
Volume of concrete in dam and power house	6,13,00,000 cft.
Total cement required	3,77,310 tons.

Spillway

Length of spillway	624 ft.
Number and size of gates. 28′ high × 40′ wide Tainter gates	13 nos.
Spillway Design capacity	3,83,000 cusecs.
Maximum Spillway capacity	4,71,000 cusecs.
Spillway bridge	13 spans each of 40′ width 22′ wide roadway and 4′-6″ side walk.
Sluices	2 Nos of 4′ × 9′.
Penstocks	6 Nos. each of 16′ dia, including 1 for future set.
Intake gates	6 nos. of 15.2′ × 27.2′ one for each penstock including 1 for future set.

Power Station Building

Length	420 ft.
Width	99 ft.
Height above generator floor	40 ft.
The building has sufficient space accommodating the 6th generating set in future.	50,000 K.W. capacity when required.
Crane	Two travelling cranes 90 tons each.

Power Plants (Ultimate)

Turbines	5 × 70,000 HP Turbines rated at 225′ head.
Generators	5 × 55,500 k.v.a. 90% power factor.
Generation	11 K.V., 3 phase 50 cycles.

Switchyard

Power Transformers	5 × 60 MVA, 11/132 kv. 2×10 MVA, 132/66 kv.

Transmission Lines and Sub-Stations

132 KV Double circuit line	385 miles.
66 KV Double circuit line	122 miles.
33 KV lines	960 miles.
11 KV lines	1,300 miles.

Grid Sub-Stations

132 KV S/S	6 Nos.
66 KV S/S	4 Nos.
33 KV S/S	55 Nos.
11 KV Sub-Station	750 Nos.

Benefits

1. Direct.

Constant Power	105 M.W.
Units generated annually	91,20,00,000 KWH.
Cost of generation at 132 kv busbars at Pipri	4.45 pies per unit.

2. Indirect.

Irrigation per year	14 lakh acres in U.P. 5 lakhs in Bihar.
Additional foodgrain per year	2,00,000 tons.
Total working expenses	Rs. 108·4 + 25·46 =Rs. 133·86 lakhs.
Net revenue	Rs. 173·44—133·86 =Rs. 39·57
Return on Capital (Rs. 659.57 lakhs)	Rs. 6.00%

Overall Projects

Gross revenue from Scale of energy under Part I and Part II	Rs. 361·20 lakhs.
Working expenses under Part I and Part II including depreciation	Rs. 104.95 lakhs.
Net Revenue	Rs. 361·20— 104·95 =Rs. 256·25 lackh.
% Return on overall Projects	Rs. 5.56%

APPENDIX II

Calculation of Annual Depreciation in accordance with E. S. Act, 1948 as supplied by the Project Authorities.

A-GENERATION

Rs. in Lakhs

Classification of assets.	Description of Assets.	Initial value in Rs. lakhs.	Share of A-Preliminaries; O-Miscellaneous; Special Tools and Plant P-Maintenance; Receipt and recoveries; Losses on stock.	Share of Establishment.	Share of interest during construction.	Total Value of Asset.	Life of Asset in years.	Rate of Depreciation in percentage.	Depreciation by sinking fund method at 3% compound interest (Col. 7×9)/100	Rate of Depreciation on straightline method, worked out by I & P Team.	
										Rate of Depreciation in percentage.	Amount.
1	2	3	4	5	6	7	8	9	10	11	12
A.	Land owned under full Title	244·87	54·43	20·036	64·819	384·155	Infinity	..	..	..	..
B.	Land held under lease	..	..	..	..	..	..	..	..	..	..
C.	Assets purchased new :										
(a)	Plant and Machinery in generating Stations. (*i*) Hydro-Electric.	250·407	55·66	20·489	66·285	392·841	35	1·485	5·834	2·857	11·223
(b)	Cooling towers & Circulating water system,	..	..	..	..	..	..	..	..	..	..
(c)	Hydraulic works forming part of a Hydro-Electric System including :—										
	(*i*) Dam and Spillway	1726·08	383·66	141·235	456·907	2707·882	100	0·15	4·062	1·0	27·079
	(*ii*) Intake outlet and Crest gates, their operating equipment, Trash racks etc.	99·65	22·15	8·154	26·378	156·332	40	1·193	1·865	2·5	3·908

(d)	Buildings and Civil Engineering works of a permanent character.	53·58	11·91	4·384	14·183	84·057	35	1·485	1·248	2·857	2·401
	(*i*) Containing Hydro-Electric generating plant.										
	(*ii*) Residential & Non-residential buildings.	48·72	10·83	3·986	12·897	76·433	50	0·8	0·611	2·0	1·529
(e)	Transformer, Transformer-Kiosks, substation equipment and other fixed apparatus.										
	(*i*) Transformer having a rating of 100 KVA and over.	37·90	8·424	3·101	10·032	59·457	35	1·485	0·883	2·857	1·699
(f)	Switchgear including cable connection.	32·65	7·26	2·672	8·643	51·225	20	3·35	1·716	5·0	2·561
(g)	Batteries	0·60	0·133	0·049	0·159	0·941	10	7·851	0·074	10·0	0·094
(h)	Cable duct System . .	12·00	2·667	0·982	3·177	18·826	60	0·555	0·105	1·666	0·314
(i)	Static Machine tools . .	4·00	0·889	0·327	1·059	6·275	20	3·35	0·210	5·0	0·314
(j)	Air Conditioning Plant (Static).	0·60	0·133	0·049	0·159	0·941	15	4·839	0·046	6·666	0·063
(k)	Internal wiring Including fittings and apparatus.	6·91	1·536	0·565	1·829	10·840	15	4·839	0·525	6·666	0·722
(l)	Communication equipment :										
	(*i*) Station Carrier Communication system complete for feeders.	2·50	0·556	0·205	0·662	3·923	15	4·839	0·190	6·666	0·262
	(*ii*) Station internal telephone system complete.	0·80	0·178	0·066	0·212	1·256	20	3·35	0·042	5·0	0·063
		2521·267	560·416	206·30	667·401	3955·384			17·411		52·232

90% of this Rs. 46·98 lakhs.

APPENDIX III

Details of working expenses as supplied by the Project authorities.

GENERATION

	Sl. No.	Item.	Amount Rs. in lakhs.
	1.	Establishment, Leave, Pension etc. as per Appendix V	12·00
Total capital cost Rs. 2301·597 lakhs.	2.	Maintenance and Repairs:	
		(a) Building and Structures @ 2% on Rs. 48·72 lakhs	0·97
		(b) Dam and Power House and Spillway including gates etc. 0.25% on Rs. 1882·72 lakhs .	4·71
		(c) Reservoir clearance and rim treatment 2% on Rs. 25·20 lakhs	0·50
		(d) Power Plant 0.75 per cent on Rs. 344·957 lakhs .	2·59
			20·77
	3.	Annual depreciation as per Appendix VI . . .	17·41
		TOTAL	38·18

APPENDIX IV

Equipment purchased directly by the contractor under T. C. M. aid as supplied by the Project authorities.

Sl. No.	Brief details of equipment.	Unit.	Total cost in Rs.
1	2	3	4
	PLANT AT QUARRY		
1	Two stage double acting compressor 820 cft. with motors	4	1,35,154
2	Secondary crushing and screening plant . . .	..	11,30,416
3	Belt conveyor assembly	..	8,10,342
4	Rear Dump Euclids 15 tons capacity	6	9,53,626
5	Kubit impact breakers with motors	3	2,47,482
6	Rows chain feeder without motor	1	99,570
7	Welding Machines	2	42,506
8	Overhead travelling crane	1	78,183
9	2½ cuyd. Ward Leonard electric shovel 54 . . .	2	11,14,964
10	Motor for primary crusher	1	38,274
11	Sand Plant Bovel Classifier torque thickner etc. . .	..	4,37,895
12	Primary Gyratory Crusher	1	7,15,495
13	200T. bicable ropeway 1150′ components of ropeway .	1	17,81,039
14	2½ cuyd. capacity shovel with Murphy diesel engine & 100′ boom	2	10,70,601
	AT DAM SITE		
1	20 tons capacity radial cableways	2	64,72,585
2	Belt conveyor assembly plant	1	5,14,254
3	Two stage double acting compressors 520 cft. with motors	1	33,784
4	10T. 3 motors electrically driven Crane with 130′ jib .	2	3,33,939
5	Multistage centrifugal pump 100 H.P. 500 gal. capacity .	6	1,66,151
6	Meter gauge diesel	3	1,07,484
7	Lighting arrestors Switches, transformers, cables, etc. .	..	4,11,725
8	Electrical equipment	..	1,57,697

APPENDIX IV—*contd.*

1	2	3	4
9	Workshop Machinery	..	3,02,452
10	Welding Machines	3	63,760
11	Shearing Machine	1	49,345
12	Transformer Oil Filter	..	8,284
13	Vulcanising Unit	1	14,978
14	Overhead travelling Crane 25 tons	1	75,227
15	Flood Lights	..	83,985
16	Components of 10 tons cableways	..	1,58,895
17	Conveyor Beltings	..	1,39,179
18	Batching Plant 980 cuyd. capacity	..	5,78,833
19	4 cuyd. keehring tilting mixers	4	9,19,312
20	American 40 ton capacity crawlar mounted crane .	2	7,56,862
21	Bulk Cement carrier Tractors & Trailors . . .	20 18	24,63,903
22	20T. capacity 28B Bycyrus Eric Cranes . . .	1	2,74,244
23	Cooling Plant Motors	1	2,07,536
24	Cooling Plant Compressors.	1	2,87,570
25	8 cuyd. concrete Buckets	7	1,64,226
26	Frequency changers.	..	44,193
27	Vibrators	..	1,85,773
28	Burndy Electric Connectors	..	14,562
		Rs.	2,36,51,285

These charges do not include cost of foundation works.

APPENDIX V

Equipment Procured by the Department under T. C. M. aid and handed over to the Contractor as supplied by Project Authorities.

Description of machinery.	Unit.	Value in Rs. at F.O.R. Robertsganj.
A. QUARRY PLANT		
Jack Hammers	36 Nos.	75,600·00
D-8 Tractor with Dozer	1 ,,	1,25,000·00
Portable Leroi Air Compressor	1 ,,	47,200·00
Teeth Ripper with detachable teeth	1 ,,	19,000·00
Concrete Mixer Jaegar	1 ,,	20,100·00
Wagon Drills	4 ,,	56,000·00
	TOTAL Rs.	3,42,900·00
B. DAM SITE PLANT		
Willys Jeep with Accessories	8 Nos.	1,04,000·00
D-8 Tractor with Dozer	1 ,,	1,25,000·00
Portable Leroi air Compressor	2 ,,	1,60,000·00
Arc Welding Sets	2 ,,	26,500·00
Truck Tractors	2 ,,	1,30,000·00
Flat rake stake body semi-trailors	2 ,,	60,000·00
Medium duty Gasoline Driven, truck (flat rake stake body)	1 ,,	32,000·00
	TOTAL Rs.	6,37,500·00
	GRAND TOTAL Rs.	9,80,400·00

APPENDIX -VI

Equipment Purchased by the Contractors in India as supplied by the Project Authorities.

Particulars of Machinery.	Unit.	Value in Rs. F.O.R. (Place of purchase).
AT QUARRY		
Rabu Metal Drill	1 No.	895 2 0
Kirloskar D.S.M. Pump	1 ,,	2,133 0 0
Motor Cycle	1 ,,	4,668 0 0
Electric Grinder Drill	2 ,,	897 0 0
G.E.C. Witton. 75 H.P. 1450 rpm. motors	4 ,,	32,832 0 0
Kirloskar D. S. M. Pump	2 ,,	4,081 0 0
Keith Blackmen Fan	1 ,,	1,200 0 0
"Atlas" Rock Drills	4 ,,	4,186 0 0
Pneumatic reversible Drill	2 ,,	2,330 0 0
Crompton Parkinson 20 H.P. Slipring Motor	1 ,.	3,078 0 0
Crompton Parkinson 20 H.P. Slipring Motor	1 ,,	3,119 13 0
Crompton Parkinson 20 H.P. Slipring Motor	1 ,,	2,565 0 0
Atlas Copco Rock Drill Type-4 (Jack Hammers)	4 ,,	5,000 0 0
Electric Motor 7.5 H.P.	1 ,,	1,852 8 0
Allis Chalmer diesel tractor	1 ,,	14,140 0 0
	TOTAL Rs.	82,977 7 0

APPENDIX VI—*contd.*

List of Equipment Purchased by M/S Hindustan Construction Co., Ltd. in India.

Particulars of Machinery.	Unit.	Value in Rs. F. O. R. (Place of purchase).
AT DAM SITE		
Drilling Machine	1 No.	497 4 3
Pneumatic Grinder	1 ,,	556 15 0
Electric Pumping set 34 H.P.	1 ,,	4,778 6 0
Lister Power driven Pump	1 ,,	869 8 0
Jeep Trailer	1 ,,	900 0 0
Jeep	1 ,,	13,389 2 0
Dodge Trucks	4 ,,	61,747 2 0
Fargo Trucks	4 ,,	63,590 14 0
Semi Rotary Pump 2″	1 ,,	153 14 0
Desoto Trucks	3 ,,	63,284 6 0
Deaning (U.S.A.) Centrifugal Pump.	1 ,,	1,375 0 0
Climax rock drills	6 ,,	6,420 0 0
Vibrators	2 ,,	3,533 12 6
Chasis with Dodge Engine	4 ,,	65,785 8 0
Pumps Centrifugal	4 ,,	19,204 12 0
Dodge Pickup	1 ,,	15,585 8 9
Diesel driven pumping set	1 ,,	4,294 1 0
Cooper grade I Sharpening Model, 24″ length	1 ,,	17,828 1 6
G.E.O. Transformer 11000/400 V	1 ,,	8,689 10 0
Motor Cycle	1 ,,	4,667 0 0
Kirloskar D.S.M. Pump	1 ,,	2,132 0 0
Electric Grinder Drill	3 ,,	897 0 0

APPENDIX VI—*contd.*

Particulars of Machinery.	Unit.	Value in Rs. F. O. R. (Place of purchase)
"Atlas" Rock Drill	4 No.	4,187 0 0
Kirloskar D.S.M. Pump	1 ,,	2,040 0 0
Crompton Parkinson 20 H.P. Slipring Motor	1 ,,	3,078 0 0
Willys Utility Van	1 ,,	18,156 8 0
Willys Jeeps	2 ,,	23,879 1 9
Ambulance	1 ,,	17,611 0 6
Slipring Motor 30 H.P. G.E.C. 960 rpm.	1 ,,	5,485 0 0
Electric Motor	1 ,,	704 0 0
Electric Motor Squirrel cage 15 H.P.	1 ,,	1,807 8 0
Cooper Oil Engine R.C.A. type	1 ,,	3,019 8 0
Refrigeration Plant Equipment	..	2,01,237 8 0
Tool & Cutting Grinder	1 No.	8,910 0 0
Auto Diesel 10 H.P. Pump	1 ,,	5,437 8 0
Broomwade Air Compressor	1 ,,	2,875 0 0
Fiat Cars	2 ,,	18,224 6 0
Broomwade Air Compressor	1 ,,	2,875 6 0
Screen protected slipring 40 H.P. Starter	1 ,,	8,175 0 0
Voltas room air conditioner (Crystal)	2 ,,	4,912 0 0
Broomwade Stationery Cooled air compressor	1 ,,	1,785 0 0
Petrol Winches	4 ,,	10,000 0 0
Petrol Engine (Waukisha)	1 ,,	5000 0 0
Petrol Winch	1 ,,	2,50 0 0
Fuel Pump Test Equp.	1 ,,	7,139 0 0
Kirloskar B.S.A. Pump	2 ,,	153 12 0
Turbine Pump with gear head	1 ,,	1,812 8 0
Ritz High Pressure Pump	1 ,,	5,842 0 0
Electric 25 H.P. Pumping set	1 ,,	6,562 8 0
Cooper Engine 28/31 H.P.	1 ,,	8,127 2 6

APPENDIX VI—*Concld.*

Particulars of Machinery.	Unit.	Value in Rs. F. O. R. (Place of purchase).
Goodwin ACME Fixed stone breaker . . .	1 No.	14,998 11 6
Ritz Turbine Pump	1 ,,	7,341 14 0
Plate Bending machine Hercules German Make . .	3 ,,	19,500 0 0
	TOTAL RS.	7,79,066 11 3
		82,977 7 0
	GRAND TOTAL RS.	8,62,044 2 3

APPENDIX VII

Equipment Brought by the Contractor from Vaitarna Works as supplied by the Project Authorities.

Details of equipment.	Unit.	Original cost (in Rs.).
10 ton cableways	2 Nos.	12,00,000
200 ton capacity jaw crusher	1 ,,	4,00,000
Ropeway	1 ,,	10,00,000
Shovels H.P. 1.5 cuyds capacity	2 ,,	5,00,000
R.B. 43 shovel 1.75 cuyds.	1 ,,	3,00,000
Aveling Barford dumpers	7 ,,	3,50,000
Cement Carriers	7 ,,	3,50,000
Refrigeration units 300 tons capacity	2 ,,	8,50,000
Euclid dumpers	2 ,,	3,00,000
	TOTAL Rs.	52,50,000

NOTE. 1. The list does not include smaller miscellaneous equipment.

2. This plant was used at Vaitarna and the depreciation is not reflected in the above prices.

3. The carriage charges to Rihand Works are not included in the above.

APPENDIX VIII

List of Equipment which the Govt. will take back from M/S H. C. C. under terms of Contract.

(CLAUSE-33.1)

Details of equipment	Units	Total Cost (Rs.)	30 p. c. price to be paid by department as per terms of contract (Rs.)
1. 20 ton Capacity radial cable-ways.	2	57,59,766	17,27,930
2. Batching & Mixing Plant			
(a) Batching Plant	1	4,31,382	
(b) Koenring 4 cuyd. tilting mixers.	4	9,19,312	
	TOTAL	13,50,694	4,05,208
3. Cooling Plant			
(a) Motors	1	58,203	
(b) Compressors	1	2,87,570	
	TOTAL	3,45,773	1,03,732
	GRAND TOTAL	74,56,233	22,36,870

GIPN—S2—4 Project (N.D.)/62—14-6-63—1,000